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THE

Patten

CANADIAN

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AND PROCEEDINGS OF THE

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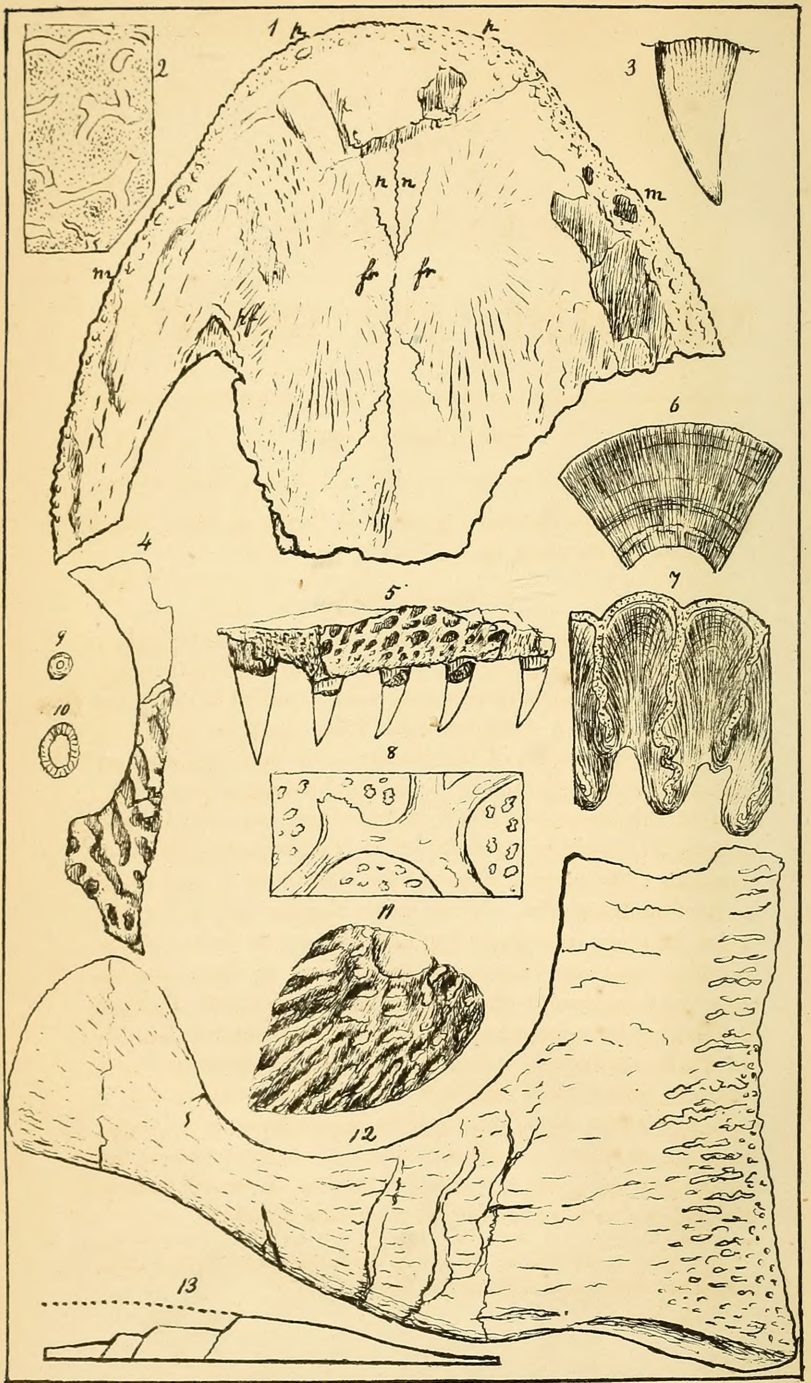

I.W.D. del.t

BAPHETES PLANICEPS, *Owen*.

THE

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VOL. VIII. FEBRUARY, 1863. No. 1.

ART. I.—*The Air-Breathers of the Coal Period in Nova Scotia* by J. W. DAWSON, LL.D., F.R.S., &c.

I. INTRODUCTORY.

The animal population of the earth during the older or palæozoic period of its geological history, is known to us chiefly through the medium of remains preserved in rocks deposited in the bed of the ocean. In such rocks we have little reason to expect an abundant representation of the animals of the land, even if these existed at the time plentifully on the neighbouring shores. Perhaps for this reason,—perhaps because there were then no land animals, the organic remains of the Cambrian, Silurian, and Lower Devonian rocks consist, in so far as animal life is concerned, solely of marine species. In the Upper Silurian and Lower Devonian, however, land plants begin to appear; and in the Upper Devonian these are so numerous and varied as to afford a probability that animals also tenanted the land. Indeed, Mr. Hartt, of St. John, has just announced the discovery of remains, which he believes to be attributable to insects, in the rich plant-bearing Upper Devonian beds of that locality.* It is true also that reptiles of high organization have been found in beds referred to the Upper Devonian, at Elgin, in Scotland; but so much doubt rests on the age of these beds, that it is unsafe at present to regard them as affording evidence of reptilian life at so early a period.

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* In a letter to the author. It is to be hoped that descriptions of these interesting remains may soon be published.

That there was dry land, even in the Lower Silurian period, we know, and can even trace its former shores. In Canada our old Laurentian coast extends for more than a thousand miles, from Labrador to Lake Superior, marking the southern border of the nucleus of the American continent in the Lower Silurian period. Along a great part of this ancient coast we have the sand-flats of the Potsdam Sandstone, affording very favorable conditions for the imbedding of land animals, did these exist; still, notwithstanding the zealous explorations of the Geological Survey, and of many amateurs, no trace of an air-breather has been found. I have myself followed the Lower Silurian beds up to their ancient limits in some localities, and collected the shells which the waves had dashed on the beach, and have seen under the Silurian beds, the Laurentian rocks pitted and indented with weather marks, showing that this old shore was then gradually subsiding; yet the record of the rocks was totally silent as to the animals that may have trod the shore, or the trees that may have waved over it. All that can be said is that the sun shone, the rain fell, and the wind blew as it does now, and that the sea abounded in living creatures. The eyes of trilobites, the weathered Laurentian rocks, the wind-ripples in the Potsdam sandstone, the rich fossils of the limestones, testify to these things. The existence of such conditions would lead us to hope that land animals may yet be found in these older formations. On the other hand, the gradual failure of one form of life after another, as we descend in the geological series, and the absence of fishes and land plants in the older Silurian rocks, might induce us to believe that we have here reached the beginning of animal life, and have left far behind us those forms that inhabit the land.

Even in the Carboniferous period, though land plants abound, air-breathers are few, and most of them have only been recently recognized. We know, however, with certainty that the dark and luxuriant forests of the coal period were not destitute of animal life. Reptiles crept under their shade, land-snails and millipedes fed on the rank leaves and decaying vegetable matter, and insects flitted through the air of the sunnier spots. Great interest attaches to these creatures; perhaps the first-born species in some of their respective types, and certainly belonging to one of the oldest land faunas, and presenting prototypes of future forms equally interesting to the geologist and the zoologist.

It has happened to the writer of these pages to have had some share in the discovery of several of these ancient animals. The coal formation of Nova Scotia, so full in its development, so rich in fossil remains, and so well exposed in coast cliffs, has afforded admirable opportunities for such discoveries, which have been so far improved that at least eight out of the not very large number of known Carboniferous land animals, have been obtained from it.* The descriptions of these creatures, found at various times and at various places, are scattered through papers ranging in date from 1844 to 1862,† and are too fragmentary to give complete information respecting the structures of the animals, and their conditions of existence. I have, for some time, designed to prepare a resumé of the published facts, with the addition of such new points as may arise from the further study of the specimens, but have been deterred by the incomplete state of my knowledge, and the prospect of further discoveries. So much has, however, now been done, and so many difficulties have been removed by the labours of several eminent naturalists who have examined the specimens, that I think the time has arrived when such a work may be undertaken with advantage to science.

In now endeavouring more fully to introduce the tenants of the coal forests of Nova Scotia to the notice of geologists and of the general reader, I shall take them nearly in the order in which they have become known to me, and shall not scruple to indulge in some gossip as to the circumstances of their discovery, and in some speculations as to their modes of life. I shall however endeavor carefully to sum up the facts ascertained as to their structure, and their relation to other creatures, whether their contemporaries or successors.

II. FOOTPRINTS.

Plate I.‡

It has often happened to geologists, as to other explorers of new regions, that footprints on the sand have guided them to the inhabitants of unknown lands. The first trace ever observed of reptiles in the carboniferous system, consisted of a series of small but well-marked footprints found by Sir W. E. Logan, in 1841, in the lower coal measures of Horton Bluff, in Nova Scotia; and as the authors of all our general works on geology have hitherto, in so far as I am aware, failed to do justice to this discovery, I shall notice it here in detail. In the year above mentioned, Sir William, then Mr. Logan, examined the coal fields of Pennsylvania and Nova Scotia, with the view of studying their structure, and extending the application of the discoveries as to Stigmaria underclays which he had made in the Welsh coal fields. On his return to England, he read a paper on these subjects before the Geological Society of London, in which he noticed the discovery of reptilian footprints at Horton Bluff. The specimen was exhibited at the meeting of the Society, and was, I believe, admitted on the high authority of Prof. Owen, to be probably reptilian. Unfortunately, Sir William's paper appeared only in abstract in the Transactions; and in this abstract, though the footprints are mentioned, no opinion is expressed as to their nature. Sir William's own opinion is thus stated in a letter to me, dated June, 1843, when he was on his way to Canada to commence the survey which has since developed so astonishing a mass of geological facts.

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* It appears that five species of Carboniferous reptiles have been recognised on the continent of Europe, three in Great Britain, and four in the United States. More full references will be made to these in the sequel.

† Papers by Lyell, Owen, and the author, in the Journal of the Geological Society of London, vols. i, ii, ix, x, xi, xvi, xvii, xviii.

‡ This plate will be given in the next number.

"Among the specimens which I carried from Horton Bluff, one is of very high interest. It exhibits the footprints of some reptilian animal. Owen has no doubt of the marks being genuine footprints. The rocks of Horton Bluff are below the gypsum of that neighbourhood; so that the specimen in question (if Lyell's views are correct*) comes from the very bottom of the coal series, or at any rate very low down in it, and demonstrates the existence of reptiles at an earlier epoch than has hitherto been determined; none having been previously found below the magnesian limestone, or to give it Murchison's new name, the 'Permian era.'"

This extract is of interest, not merely as an item of evidence in relation to the matter now in hand, but as a mark in the progress of geological investigation. For the reasons above stated, the important discovery thus made in 1841, and published in 1842, was overlooked; and the discovery of reptilian bones by Von Dechen, at Saarbruck, in 1844, and that of footprints by Dr. King in the same year, in Pennsylvania, have been uniformly referred to as the first observations of this kind. This error I now desire to correct, not merely in the interest of truth, but also in that of my friend Sir William Logan, and of my native province of Nova Scotia; and I trust that henceforth the received statement will be that the first indications of the existence of reptiles in the coal period, were obtained by Logan, in the lower coal formation of Nova Scotia, in 1841. Insects and arachnidans, it may be observed, had previously been discovered in the coal formation in Europe.

---

* Sir Charles Lyell had then just read a paper announcing his discovery that the gypsiferous system of Nova Scotia is Lower Carboniferous, in which he mentions the footprints referred to, as being reptilian.

The original specimen of these footprints is still in the collection of Sir William Logan. It is a slab of dark colored sandstone, glazed with fine clay on the surface; and having a series of seven footprints in two rows, distant about 3 inches; the distance of the impression in each row being 3 or 4 inches, and the individual impressions about 1 inch in length. They seem to have been made by the points of the toes, which must have been armed with strong and apparently blunt claws, and appear as if either the surface had been somewhat firm, or as if the body of the animal had been partly water-borne. In one place only is there a distinct mark of the whole foot, as if the animal had exerted an unusual pressure in turning or stopping suddenly. One pair of feet, the fore feet I presume, appear to have had four claws; the other pair may have had three or four, and it is to be observed that the outer toe, as in the larger footprints discovered by Dr. King, projects in the manner of a thumb, as in the chierotherian tracks of the Trias. No mark of the tail or belly appears. The impressions are such as may have been made by some of the reptiles to be described in the sequel, as, for instance, by *Dendrerpeton Acadianum.*

Attention having been directed to such marks by these observations of Sir William Logan, several other discoveries of the same kind were subsequently made, in various parts of the province, and in different members of the carboniferous system. The first of these, in order of time, was made in 1844, in beds of red sandstone and shale near Tatamagouche, in the eastern part of Nova Scotia, and belonging to the upper or newer members of the coal measures. In examining these beds with the view of determining their precise geological age, I found on the surface of some of them impressions of worm-burrows, rain drops, and suncracks, and with these, two kinds of footprints, probably of reptilian animals. One kind consisted of marks, or rather scratches, as of three toes, and resembling somewhat the scratches made by the claws of a tortoise in creeping up a bank of stiff clay; they were probably of the same nature and origin with those found by Logan at Horton. The others were of very different appearance. They consisted of two series of strongly marked elongated impressions, without distinct marks of toes, in series four inches distant from each other, and with an intervening tail mark. They seem to have been produced by an animal wading in soft mud, so that deep holes, rather than regular impressions, marked its footsteps, and that in the hind foot, the heel touched the surface, giving a plantigrade appearance to the tracks. Rain marks had been impressed on the surface after the animal had passed over it, and these had probably aided in obliterating the finer parts of the impressions. These observations were published in the Journal of the Geological Society of London, vols. 1st and 2nd.

Shortly afterward, Dr. Harding, of Windsor, when examining a cargo of sandstone which had been landed at that place from Parrsboro', found on one of the slabs a very distinct series of footprints nearly of the size of those previously observed. Dr. Harding's specimen is now in the museum of King's College, Windsor. Its impressions are distinct, and not very different in size and form from those above described as found at Horton Bluff. The rocks at that place are probably of nearly the same age with those of Parrsboro'. I afterward examined the place from which this slab had been quarried, and satisfied myself that the beds are Carboniferous, and probably Lower Carboniferous. They were ripple-marked and sun-cracked, and I thought I could detect trifid footprints, though more obscure than those in Dr. Harding's slab. Similar footprints are also stated to have been found by Dr. Gesner, at Parrsboro'.

I have since observed several instances of such impressions at the Joggins, at Horton, and near Windsor, showing that they are by no means rare, and that reptilian animals existed in no inconsiderable numbers throughout the coal-field of Nova Scotia, and from the begining to the end of the carboniferous period. Two of the more interesting examples are figured with those already described. On comparing these with one another, it will be observed that Logan's, Harding's, and one of mine are of similar dimensions and character, and may have been made by one kind of animal, possibly *Dendrerpeton*, which must have crept on short limbs over the sand. The other belongs to a smaller animal, which probably travelled on longer limbs, more in the manner of an ordinary quadruped. It may have been some species of *Hylonomus*. On the whole, these footprints differ from those found by Dr. King in Pennsylvania; but they do not prove the existence of any kind of animal distinct from those to be described in the sequel, and known to us by the preservation of portions of their skeletons.

The study of these impressions shows that the animals which produced them may, in certain circumstances, have left impressions of only two or three of their toes, while in other circumstances all may have left marks; and that, when wading in deep mud, their footprints were altogether different from those made on hard sand or clay. In some instances the impressions may have been made by animals wading or swimming in water, while in others the rain-marks and sun-cracks afford evidence that the surface was a sub-aerial one. They are chiefly interesting as indicating the wide diffusion and abundance of the creatures producing them, and that they haunted tidal flats and muddy shores, perhaps emerging from the water that they might bask in the sun, or possibly searching for food among the rejectamenta of the sea, or of lagunes and estuaries.

III. Baphetes planiceps.

Plate II.

In the summer of 1851, I had occasion to spend a day at the Albion mines; and on arriving at the railway station in the afternoon, found myself somewhat too early for the train. By way of improving the time thus left on my hands, I betook myself to the examination of a large pile of rubbish, consisting of shale and ironstone from one of the pits, and in which I had previously found scales and teeth of fishes. In the blocks of hard carbonaceous shale and earthy coal, of which the pile chiefly consisted, scales, teeth and coprolites often appeared on the weathered ends and surfaces as whitish spots. In looking for these, I observed one of much greater size than usual, on the edge of a block, and on splitting it open, found a large flattened skull, the cranial bones of which remained entire on one side of the mass, while the palate and teeth, in a more or less fragmentary state, came away with the other half. Carefully trimming the larger specimen, and gathering all the smaller fragments, I packed them up as safely as possible, and returned from my little excursion much richer than I had hoped.

The specimen, on further examination, proved somewhat puzzling. I supposed it to be, most probably, the head of a large ganoid fish; but it seemed different from any thing of this kind with which I could compare it; and at a distance from comparative anatomists, and without sufficient means of determination, I dared not refer it to anything higher in the animal scale. Hoping for further light, I packed it up with some other specimens, and sent it to the Secretary of the Geological Society of London, with an explanatory note as to its geological position, and requesting that it might be submitted to some competent osteologist for examination. For a year or two however, it remained as quietly in the Society's collection as if in its original bed in the coal mine, until attention having been attracted to such remains by the discoveries made by Sir Charles Lyell and myself in 1852, at the South Joggins, and published in 1853,* the Secretary or President of the Society re-discovered the specimen, and handed it to Prof. Owen, by whom it was described in Dec., 1853,† under the name of *Baphetes planiceps*, which may be interpreted the "flat-headed-diving animal," in allusion to the flatness of the creature's skull, and the possibility that it may have been in the habit of diving.

The parts preserved in my specimen are the bones of the anterior and upper part of the skull in one fragment, and the teeth and palatal bones in others. With respect to the former, Prof. Owen recognizes in it the premaxillary (p.) (Fig. 1) and maxillary bones, (m.) both presenting traces of the sockets of teeth, which appear to be in a single series; but other fragments show that in part at least, they were in double series. The central portion of the skull and part of the orbits are made up of the nasals, (n.) the frontal (fr.) and the prefrontal (pf.) in a manner characteristic of the Labyrinthodont reptiles, and not of fishes. The upper surface of the bone, seen in some detached fragments, as in Fig. 4, has a pitted surface, like that of the stone of a peach, as is the case also in the Labyrinthodonts. In sections under the microscope, the bone shows vascular canals and small rounded bone-cells, a structure observed, in *Labyrinthodon*, and in some of the larger Saurians (Figs. 2 and 8). The teeth are conical, and somewhat curved, the outer series from a line to two lines in diameter, and the inner series three lines or more (Figs. 3 and 5). They are implanted in shallow sockets in the maxillary and premaxillary bones, and are anchylosed to the sockets. For the lower third, the outer surface presents shallow vertical grooves, conformably with the plicated character of the internal structure (Figs. 3, 7, and 10). The upper portion is smooth, and its internal structure presents merely radiating tubes of ivory, and concentric layers, (Figs. 3, 6, and 9). The whole of these characters are regarded as allying the animal with the great crocodilian frogs of the Trias of Europe, first known as *Cheirotherians*, owing to the remarkable hand-like impressions of their feet, and afterwards as *Labyrinthodonts*, from the beautifully complicated convolutions of the ivory of their teeth.

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* Journal of Geological Society of London, vol. ix.

† Journal of Geological Society, vol. x; and additional notes, vol. xi.

The only additional remains attributable to this creature, found since the publication of Professor Owen's description, are the bone represented in Fig. 12, and the scute or scale represented in Fig. 11. The former may be a scapular or sternal bone, and, if so, would warrant the belief that the creature possessed anterior limbs of considerable size; the proportion relatively to the skull being much the same as in the American bullfrog. The latter is marked in the same way as the bones of the head, and would indicate that *Baphetes* was protected by bony dermal scales, resembling those of the crocodile.

There is one point illustrated by the bone represented in Fig. 12, to which I would earnestly invite the attention of comparative anatomists. It is the distortion to which bones are subjected when imbedded in soft deposits, especially those containing vegetable matter. In modern peat bogs, skulls have been found nearly as pliable as leather, owing to the partial removal of their phosphate of lime; and in clay beds they are often found softer than chalk, from to the removal of their animal matter. Human skulls, buried under no great weight of earth, have often been strangely distorted from this posthumous softening. Even teeth are affected in this way. In the remains of the old Indian village of Hochelaga, at Montreal, while the teeth of bears are found in the drier and more sandy soil quite perfect and unaltered, in damp places, and where they are imbedded in organic matter thrown out from the cabins, they are softened, so that a large canine may be easily compressed between the finger and thumb. Changes of this kind have no doubt been experienced by all the bones imbedded in coal, carbonaceous shale, and similar deposits; and in the great compression which the mass has experienced, the bones, yielding with it, have been flattened and distorted in the most remarkable manner. In the bones, in short, as in the plants of the coal, the flattened specimen must not be accepted as representing the original form. The bone represented in Fig. 12, for example, must have been strong, and nearly cylindrical in its middle portion, and much curved, but it has given way to pressure, and has as it were been *faulted* along certain lines, so as to lose almost entirely its original relief. The sectional view in Fig. 13, represents some of these faults, with the present profile of the bone, its original outline being represented by the dotted line. The title of the present species to the specific name *planiceps*, is also in part dependent on this cause. No doubt its head, like that of other batrachians, was somewhat flat, but this has been much increased by pressure; in so much that the fragments of the specimen show that the palate is almost brought into contact with the roof of the skull, and that scarcely a quarter of an inch is left in some places for the depth of the great orbits. The interior of the skull must have been filled with soft slime, and this has been compressed into a hard stone. In like manner, I shall have occasion to show, in reference to other reptiles of the coal, that their bones have been much altered in form, so that limb bones, which, when buried in a nearly erect position, show broad and flat articulating surfaces, have these compressed into mere edges, when the specimens lie horizontally, and that hollow bones have been fractured longitudinally, and pressed almost perfectly flat. Anatomists may be very easily misled by such appearances, and should carefully enquire as to the possibility of their occurrence, before deducing inferences from the forms of bones.

Of the general form and dimensions of *Baphetes*, the facts at present known, do not enable us to say much. Its formidable teeth and strong maxillary bones show that it must have devoured animals of considerable size, probably the fishes whose remains are found with it, or the smaller reptiles of the coal. It must in short have been crocodilian, rather than frog-like, in its mode of life; but whether, like the labyrinthodonts, it had strong limbs and a short body, or like the crocodiles, an elongated form and a powerful natatory tail, the remains do not decide. One of the limbs, or a vertebra of the tail would settle this question, but neither have as yet been found. That there were large animals of the labyrinthodontal form in the coal period, is proved by the footprints discovered by Dr. King in Pennsylvania, which may have been produced by an animal of the type of *Baphetes*. On the other hand that there were large swimming reptiles, seems established by the recent discovery of the vertebræ of *Eosaurus Acadianus*, at the Joggins, by Mr. Marsh.* The locomotion of *Baphetes* must have been vigorous and rapid, but it may have been effected both on land and in water, and either by feet or tail, or both.

With the nature of its habitat we are better acquainted. The area of the Albion Mines coal field was somewhat exceptional in its character. It seems to have been a bay or indentation in the Silurian land, separated from the remainder of the coal-field by a high shingle beach, now a bed of conglomerate. Owing to this circumstance, while in the other portions of the Nova Scotia coal field, the beds of coal are thin, and alternate with sandstones and shales, at the Albion Mines a vast thickness of almost unmixed vegetable matter has been deposited, constituting the 'main seam' of thirty-eight feet thick,and the 'deep seam' twenty-four feet thick, as well as still thicker beds of highly carbonaceous shale. But, though the area of the Albion coal measures was thus separated, and preserved from marine incursions, it must have been often submerged, and probably had connection with the sea, through rivers or channels cutting the enclosing beach. Hence beds of earthy matter occur in it, containing remains of large fishes. One of the most important of these is that known as the "Holing stone," a band of black highly carbonaceous shale, coaly matter, and clay ironstone, occurring in the main seam, about five feet below its roof, and varying in thickness from two inches to nearly two feet. It was from this band, that the rubbish-heap, in which I found the skull of *Baphetes planiceps*, was derived. It is a laminated bed, sometimes hard and containing much ironstone, in other places soft and shaly : but always black and carbonaceous, and often with layers of coarse coal, though with few fossil plants retaining their forms. It contains large round flat scales and flattened curved teeth, which I attribute to a fish of the genus *Rhizodus*, resembling, if not identical with, *R. lancifer*, Newberry. With these are double pointed shark-like teeth, and long cylindrical spines of a species of *Diplodus*, which I have named *D. acinaces*.† There are also shells of the minute *Spirorbis*, so common in the coal measures of other parts of Nova Scotia, and abundance of fragments of coprolitic matter. I have also observed in it a few scales having the peculiar one-sided form of those of *Archegosaurus* and *Dendrerpeton;* and which I may possibly describe and figure, among miscellaneous indications of unknown creatures, in the end of this memoir.

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* Silliman's Journal, 1859.

† Supplement to Acadian Geology, pp. 43 and 50.

It is evident that the "Holing stone" indicates one of those periods in which the Albion coal area, or a large part of it, was under water, probably fresh or brackish, as there are no properly marine shells in this, or any of the other beds of this coal series. We may then imagine a large lake or lagune, loaded with trunks of trees and decaying vegetable matter, having in its shallow parts, and along its sides, dense brakes of *Calamites*, and forests of *Sigillaria*, *Lepidodendron*, and other trees of the period, extending far on every side as damp pestilential swamps. In such a habitat, uninviting to us, but no doubt suited to *Baphetes*, that creature crawled through swamps and thickets, wallowed in flats of black mud, or swam and dived in search of its finny prey. It was, in so far as we know, the monarch of these swamps, though there is evidence of the existence of similar creatures of this type quite as large in other parts of the Nova Scotia coal field; but my notice of these I defer for the present, in hope that additional facts may be discovered in respect to them. If this should not be the case they will be noticed among miscellaneous remains in the sequel.

EXPLANATION OF PLATE II.

Baphetes planiceps.

Fig. 1.—Skull seen from below, half natural size.
" 2.—Portion of bone of skull magnified, to show vascular canals and bone-cells.
" 3.—One of the largest teeth, natural size.
" 4.—Sculpturing of skull, and margin of orbit, natural size.
" 5.—Fragment of maxillary bone, with four teeth of the outer series, and one of the inner large teeth,—the points of the teeth restored from fragments in other specimens.
" 6 and 7.—Sections of a tooth magnified: 6, upper part; 7, lower part, with convoluted dentine.
" 8.—Section of bone in Fig. 2, more highly magnified.
" 9 and 10.—Sections of tooth represented in Figs. 6 and 7, natural size.
" 11.—Dermal scale found with remains of *Baphetes*.
" 12.—Scapular or sternal bone found with remains of *Baphetes*.
" 13.—Longitudinal section of the middle of the same, showing the manner in which it has been crushed.

(*To be continued.*)

ART. II.—*On the Gold Mines of Canada, and the manner of working them.*

The existence of gold in the sands of the Chaudière valley, to the south of Quebec, was, so far as we are aware, first announced to the world by General Baddeley (then Lieutenant) of the Royal Engineers, in the year 1835, and by him communicated to Prof. Silliman. (see American Journal of Science for that year, vol. xxviii. p. 112.) In 1847, and the three or four years following, careful examinations were made in that region by the Geological Survey, and it was found that the precious metal is not confined to the valley of the Chaudière, but exists in the superficial deposits of a wide area.

The source of the gold throughout this extent appears to have been the breaking up of the crystalline schists of the region, in which the metal has occasionally been met with. One example of this is in a vein of quartz in clay state, in the parish of St. Francis, on the Chaudière, where it occurs with argentiferous galena, arsenical pyrites, cubic iron pyrites and sulphuret of zinc,—the latter two ores containing a notable proportion of gold. The results of assays of all these materials will be found in the reports of the Geological Survey for 1853, page 370. During the past year, another vein of quartz, about one hundred yards from this last has yielded very rich and beautiful specimens of native gold, also accompanied by arsenical pyrites. The precious metal occurs again not far from the Harvey Hill copper mine, in Leeds, at a locality known as Nutbrown's shaft, which is sunk on a vein of bitter-spar, holding specular iron, vitreous copper ore, and native gold, generally in small grains or scales. Some specimens from this locality, however, have weighed as much as a pennyweight. The only attempts as yet made at gold-mining in Canada have been in the diluvial deposits. We extract from the General Report of the Geological Survey of Canada, now in press, and soon to appear, the following details with regard to these deposits, together with the results of some of the trials hitherto made to work them, and suggestions as to the best mode of obtaining the gold.

"These rocks of eastern Canada may be traced south-westwardly through New England, along the Appalachian chain, to the state of Georgia, and furnish gold in greater or less quantity in nearly every part of their extension. They constitute the great gold-bearing formation of eastern North America, which in its mineralogical and lithological characters is similar to that of the western coast, and to those of Russia and Australia. These auriferous rocks in Canada, belong for the greater part to the Quebec group, of Lower Silurian age; but the quartz veins containing gold, mentioned above, are found cutting strata, which are supposed to belong to the Upper Silurian period. The auriferous drift covers a wide area on the south side of the St. Lawrence, including the hill country belonging to the Notre Dame range, and extending thence south and east to the boundary of the province. These wide limits are assigned, inasmuch as although gold has not been everywhere found in this region, the same mineralogical characters are met with throughout. In its continuation southward in Plymouth, and elsewhere in Vermont, considerable quantities of gold have been obtained from the diluvial deposits. In Canada, gold has been found on the St. Francis River, from the vicinity of Melbourne to Sherbrooke; in the townships of Westbury, Weedon, and Dudswell, and on Lake St. Francis. It has also been found on the Etchemin, and on the Chaudière, and nearly all its tributaries, from the seigniory of St. Mary to the frontier of the state of Maine; including the Bras, the Guillaume, the Rivière des Plantes, the Famine, the Du Loup, and the Metgermet. Several attempts have been made to work these alluvial deposits for gold, in the seigniories of Vaudreuil, Aubert-Gallion, and Aubert de l'Isle, but they have been successively abandoned; and it is difficult to obtain authentic accounts of the result of the various workings, although it is known that very considerable quantities of gold were extracted. The country people still, from time to time, attempt the washing of the gravel, generally with the aid of a pan, and are occasionally rewarded by the discovery of a nugget of considerable value. In the years 1851 and 1852, an experiment of this kind, on a considerable scale, was tried by the Canada Gold Mining Company, in the last named seigniory, on the Rivière du Loup, near its junction with the Chaudière. The system adopted for the separation of the gold from the gravel was similar to that used in Cornwall in washing for alluvial tin, and the water for the purpose was obtained from a small stream adjoining. Great difficulties were however met with, from a deficient supply of water during the summer months. The gravel from about three-eighths of an acre, with an average thickness of two feet, was washed during the summer of 1851, and yielded 2,107 pennyweights of gold; of which 160 were in the form of fine dust, mingled with about a ton of black iron sand, the heavy residue of the washings. There were several pieces of gold weighing over an ounce. The value of this gold was $1,826, and the whole expenditure connected with the working $1,643, leaving a profit of $182. In this account is, however, included $500 lost by a flood, which swept away an unfinished dam ; so that the real difference between the amount of the wages and the value of the gold obtained should be stated at $682. The average price of the labor employed was sixty cents a day."

" In 1852, about five-eighths of an acre of gravel were washed at this place, and the total amount of gold obtained was 2,880 pennyweights, valued at $2,496. Of this, 307 pennyweights were in the form of fine dust mixed with the iron sand. A portion was also found in nuggets or rounded masses of considerable size. Nine of these weighed together 468 pennyweights, the largest being about 127, and the smallest about 11 pennyweights. Small portions of native platinum, and of iridosmine, were obtained in these washings, but their quantity was too small to be of any importance. The washing season lasted from the twenty-fourth of May to the thirtieth of October, and the sum expended for labor was $1,888, leaving a profit of $608. A part of this expenditure was, however, for the construction of wooden conductors for bringing the water a distance of about 900 feet from the small stream. As this work would be available for several years to come, a proper allowance made for it would leave a profit in the year's labor of about $680. It thus appears that from an acre of the gravel, with an average thickness of two feet, there were taken $4,323 of gold ; while the expenses of labor, after deducting, as above, all which was not directly employed in extracting gold, were $2,957, leaving a profit of $1,366. The fineness of the gold dust of this region was 871 thousandths ; another sample in thin scales gave 892, and masses 864. A small nugget of gold from St. Francis gave 867 thousandths, the remainder in all cases being silver."

" Although the greater part of this gold was extracted from the gravel on the flats by the river side, a portion was obtained by washing the material taken from the banks above. As has been before remarked, the distribution of the gold-bearing gravel over the surface of the country took place before the formation of the present water courses, and the reason why the gravel from the beds of these are richer in gold than that which forms their banks, is that these rapid streams have subjected the earth to a partial washing, carrying away the lighter materials, and leaving the gold behind with the heavier matters. According to Mr. Blake, it is found in California, that the gold in the diluvial deposits, which have not been subsequently disturbed by the streams, is not uniformly distributed, but is accumulated here and there in quantities greater than in other places. It would seem that during the first deposition of the earth and gravel, the precious metal became in some parts accumulated in depressions of the surface rock, constituting what are called pockets by the miners. It would appear from the facts here given that the quantity of gold in the valley of the Chaudière is such as would be remunerative to skilled labour, and should encourage the outlay of capital. There is no reason for supposing that the proportion of the precious metal to be found along the St. Francis, the Etchemin, and their various tributaries, is less considerable than that of the Chaudière."

"What is called the hydraulic method of washing deposits of auriferous gravel is adopted on a great scale in California, and to some extent in the states of Georgia and North Carolina. In this method, the force of a jet of water, with great pressure, is made available, both for excavating and washing the auriferous earth. The water, issuing in a continuous stream, with great force, from a large hose-pipe, like that of a fire-engine, is directed against the base of a bank of earth and gravel, and tears it away. The bank is rapidly undermined, the gravel is loosened, violently rolled together, and cleansed from any adhering particles of gold; while the fine sand and clay are carried off by the water. In this manner hundreds of tons of earth and gravel may be removed, and all the gold which they contain liberated and secured, with greater ease and expedition than ten tons could be excavated and washed in the old way. All the earth and gravel of a deposit is moved, washed, and carried off through long sluices, by the water, leaving the gold behind. Square acres of earth on the hill sides may thus be swept away into the hollows, without the aid of a pick or a shovel in excavation. Water performs all the labor, moving and washing the earth, in one operation; while in excavating by hand, the two processes are of necessity entirely distinct. The value of this method, and the yield of gold by it, as compared with the older one, can hardly be estimated. The water acts constantly, with uniform effect, and can be brought to bear upon almost any point, where it would be difficult for men to work. It is especially effective in a region covered by trees, where the tangled roots would greatly retard the labor of workmen. In such places, the stream of water washes out the earth from below, and tree after tree falls before the current, any gold which may have adhered to the roots being washed away. With a pressure of sixty feet, and a pipe of from one and a half to two inches aperture, over a thousand bushels of earth can be washed out from a bank in a day. Earth which contains only one twenty-fifth part of a grain of gold, equal to one-fifth of a cent in value to the bushel, may be profitably washed by this method ; and any earth or gravel which will pay the expense of washing in the old way, gives enormous profits by the new process. To wash successfully in this way requires a plentiful supply of water, at an elevation of from fifty to ninety feet above the bed-rock, and a rapid slope or descent from the base of the bank of earth to be washed, so that the waste water will run off through the sluices, bearing with it gravel, sand, and the suspended clay."

" The above description, and the added details are copied from a report on the gold mines of Georgia, by Mr. William P. Blake, who has carefully studied this method of mining in California, and by whose recommendation it has been introduced into the southern states. He states that in the case of a deposit in North Carolina, where ten men where required, for thirty-five days, to dig the earth with pick and shovel, and wash it in sluices, two men, with a single jet of water, would accomplish the same work in a week. The great economy of this method is manifest from the fact that many old deposits in the river beds, the gravel of which had been already washed by hand, have been again washed with profit by the hydraulic process. He tells us that in California the whole art of working the diluvial gold deposits was revolutionized by this new method. The auriferous earth, lying on hills, and at some distance above the level of the water-courses, would, in the ordinary methods, be excavated by hand, and brought to the water; but by the present system, the water is brought by aqueducts to the gold deposits, and whole square miles, which were before inaccessible, have yielded up their precious metal. It sometimes happens, from the irregular distribution of the gold in the diluvium in California, that the upper portions of a deposit do not contain gold enough to be washed by the ordinary methods ; and wonld thus have to be removed, at a considerable expense, in order to reach the richer portions below. By the hydraulic method, however, the cost of cutting away and excavating is so trifling, that there is scarcely any bank of earth which will not pay the expense of washing down, in order to reach the richer deposits of gold beneath.

" The acqueducts or canals for the mining districts of California are seldom constructed by the gold workers themselves, but by capitalists, who rent the water to the miners. The cost of one of these canals, carrying the waters of a branch of the Yuba River to Nevada County, was estimated at a million of dollars ; and another one, thirty miles in length, running to the same district, cost $500,000. The assessed value of these various canals in 1857 was stated to be over four millions of dollars, of which value one-half was in the single county of Eldorado. The Bear River and Auburn Canal is sixty miles in length, three feet deep and four feet wide at the top, and cost in all $1,600,000 ; not withstanding which, the water-rents were so great that it is stated to have paid a yearly dividend of twenty per cent, while other similar canals paid from three, to five and six per cent., and even more, monthly. The price of the water was fixed at so much the inch, for each day of eight or ten hours. This price was at first about three dollars, but by competition has now been greatly reduced.

" From these statements, it will be seen that the great riches which have of late years been drawn from the gold mines of California, have not been obtained without the expenditure of large amounts of money and engineering skill. This last is especially exhibited in the construction of these great canals, and the application of the hydraulic method to the washing of auriferous deposits, which were unavailable by the ordinary modes of working, on account of their distance from the water-courses, or by reason of the small quantity of gold which they contain.

" In order to judge of the applicability of this method of washing to our own auriferous deposits, a simple calculation based upon the experiments at the Rivière du Loup will be of use. It has been shown that the washing of the ground over an area of one acre, and with an average depth of two feet, equal to 87,120 cubic feet, gave, in round numbers, about 5000 pennyweights of gold, or one and thirty-eight hundredths grains to the cubic foot; which is equal to one and three-quarters grains of gold to the bushel. Now, according to Mr. Blake, earth containing one forty fourth part of this amount, or one twenty-fifth of a grain of gold, can be profitably washed by the hydraulic method, while the labor of two men, with a proper jet of water, suffices to wash one thousand bushels in a day, which in a deposit like that of Rivière du Loup would contain about seventy-three pennyweights of gold. It is probable however that a certain portion of the finer gold dust, which is collected in the ordinary process, would be lost in working on the larger scale. It has already been shown that the gold is not confined to the gravel of the river channels, and the alluvial flats. The beds of interstratified clay, sand, and gravel, which occur on the banks of the Metgermet, were found to contain gold throughout their whole thickness of fifty feet, and even though its proportion were to be many times less than in the gravel of the Rivière du Loup, these thick deposits, which extend over great areas, might be profitably worked by the hydraulic method. The fall in most of the tributaries of the Chaudière and of the St. Francis throughout the auriferous region, is such that it will not be difficult to secure a supply of water with a sufficient head, without a very great expenditure in the construction of canals ; and it may reasonably be expected that before long the deposits of gold-bearing earth, which are so widely spread over southeastern Canada, will be made economically available."

T. S. H.

ART. III.—*On the Parallelism of the Quebec Group with the Llandeilo of England and Australia, and with the Chazy and Calciferous formations*; by E. BILLINGS, F.G.S.

(*Read before the Nat. Hist. Society of Montreal*, *3rd Feb.* 1863.)

In the following paper, it is proposed to review some of the more prominent facts and opinions relating to the age of the Quebec group, as compared with certain other formations in Europe, Australia, and America, whose true position is well established. During the last four years, great progress has been made towards the solution of this problem, and a general conclusion has been arrived at, which I believe will stand the test of time. But the subject is far from being exhausted. There yet remain numerous secondary and collateral questions of more or less difficulty, which can be only decided by much further investigation in the field. In the meantime, the tract of country wherein these rocks are most extensively developed, has become of great importance, on account of its stores of mineral wealth; and everything therefore relating to its geological structure, is of interest, not only in a scientific, but also in an economical point of view.

In 1860, Sir W. E. Logan, after having re-examined the whole subject, came to the conclusion that the position, to which these rocks had been previously referred, was too high up in the series, and that they lie near the base, rather than in the upper half of the Lower Silurian. This opinion was published in the Canadian Naturalist and Geologist of December, in the same year.* Since that time a vast deal of new evidence has been collected, all tending to prove that this view is the correct one. Endeavours are being made, however, by means of pamphlets, published by Mr. Marcou, of Boston, and circulated in Canada, the United States, and Europe, to show that the Quebec group does not belong to the Lower Silurian at all, and that it lies below the Potsdam sandstone, in the primordial zone. But unfortunately for this theory, the papers containing the physical and palæontological evidence, published by the Canadian Survey, are in the hands of all the great European geologists, and have furnished them with the means of forming their own opinions upon the subject. The views of these men, are to us of the highest value, coming as they do from those who by their world-wide experience and oft tested ability, are acknowledged on all hands, to be the highest authorities on all that relates to the lower palæozoic formations.

Sir R. I. Murchison, in his address to the Geological Section of the British Association, in 1861, publicly announced his entire concurrence with us in the important change that had been made.

M. J. Barrande has, in several papers published in the Bulletin of the Geological Society of France, and in Bronn's Neues-

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* The fossils upon which the age of the Quebec group was determined were collected in May and June, 1860. On the 12th of July I wrote to Barrande, informing him of the discovery, and that they (the fossils) proved that the Point Levis rocks belonged to a horizon near the base of the second fauna. In August, I published the descriptions of the trilobites in the Canadian Naturalist and Geologist, and on that occasion the use of the designation "Hudson River Group," as the name of the formation was first discontinued. Barrande communicated (in a letter dated Paris, 14th August, 1860,) the substance of my letter to Mr. Marcou, and it was by him published in the proceedings of the Boston Natural History Society in November following.

Jahrbuch, pronounced the greater number of the fossils, described and figured by us from the Quebec group, to be Lower Silurian, while in his opinion the others present a primordial aspect.

Prof. F. McCoy, Director of the National Museum of Victoria, in Australia, in a paper published in the Annals of Natural History in February, 1862, announced the discovery of the compound graptolites of the Quebec group "in the slates of North Melbourne containing the auriferous quartz-veins of the gold-fields."* He identified the Australian slates with the Llandeilo rocks of Wales, Scotland and Ireland on the one hand, and with the Quebec group on the other. The compound graptolites were first discovered and brought into notice by the Canadian Survey; and it is to us a source of great satisfaction, that they have now become, in the hands of skilful palæontologists the means, by which rocks, separated from each other by a distance nearly equal to half the circumference of the globe, can be proved to be of the same geological age. The gold fields of the Chaudière, near Quebec, appear thus to lie in the same horizon with those of Australia. It would also seem, that the compound, differ from the simple graptolites, in being more persistently confined to a particular period near the base of the Lower Silurian.

Prof. R. Harkness and **J. W. Salter**, on the 17th of December last, read a paper before the Geological Society, which bears so importantly upon our discoveries in the Quebec group that I shall quote the abstract of it entire as published in the Geologist of January, 1863. It is as follows:—

> *December* 17*th.*—"On the Skiddaw Slate Series." By Prof. R. Harkness; with a note on the Graptolites, by Mr. J. W. Salter. Some general sections through the Skiddaw Slates were described in detail, and the localities in which fossils had been previously found by Professor Sedgwick were especially noticed. The author stated that he had discovered several species of Graptolites, new to the Skiddaw Slates, in certain flaggy beds almost devoid of cleavage, which occur at intervals in the lower portion of the series, in several localities. Professor Harkness showed that these rocks were much more fossiliferous than had hitherto been supposed; and that the evidence of the fossils, as interpreted by Mr. Salter, clearly proved them to be of the same age as the Lower Llandeilo rocks of Wales, and the Quebec group of Canada. The thickness of the Skiddaw Slates was estimated at 7000 feet, and the total thickness from the base of the Skiddaw Slates to the Coniston limestone

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* It does not seem to be clearly proved that the gold actually belongs to the graptolitic slates.

at 13,000 feet. Besides several species of well-known Graptolites that are also found in the Lower Llandeilo rocks and in the Quebec group (Taconic System),* Mr. Salter has been enabled to identify *Phyllograpsus angustifolium*, Hall, *Tetragrapsus bryonoides*, Hall, and another species of that genus, *Dichograpsus Sedgwicki*, n. sp., *Didymograpsus caduceus*, and some others. He has given the name of *Caryocaris Wrightii* to a Crustacean discovered in these rocks by Mr. Wright. Mr. Salter considers the Skiddaw Slates to be of the same age as the Quebec Group, the graptolitiferous rocks of Melbourne, and the Tremadoc Slates of Wales.

All the above proves, clearly enough, that in the opinion of the best European geologists, the age of the Quebec group has been correctly determined by the Canadian Survey. In Sir W. E. Logan's first paper it is stated that "*it appears to be a great development of strata about the age of the Chazy and Calciferous*," and it is well known that for several years past these two formations have been classified in the Provincial Geological Museum as representing the Llandeilo. The cards placed in the cases to indicate this parallelism, refer the Calciferous to the Lower, and the Chazy to the Upper Llandeilo. This must be understood in a general sense, because, as in England it is impossible to point out the identical line of demarcation between the Llandeilo and the Lingula flags below, or between the Llandeilo and the Bala group above, so it is (with more reason) not possible to parallel, bed for bed, the American with the European sub-divisions of these ancient formations. The great point decided by the Canadian Survey in 1860 is this,—that the Quebec group is not the upper part of the Lower Silurian to which it had always been referred by some geologists; neither does it lie in the primordial zone, as was then and is still maintained by others, but it occupies a position between these two levels.

The fossils of the Quebec group, are mostly all new species, those which are not new being specifically identical with those which occur in the Chazy and Calciferous, in the typical localities of the north-western division of the Silurian of Canada and New York, where the strata are undisturbed. But not one species has been found which occurs in the Hudson River formation. There are some species of *Orthoceras Murchisonia* and *Pleurotomaria* that might be at first sight taken for well known Trenton or Black

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* The Quebec group is only in part Taconic, as it includes rocks which Emmons expressly excluded. I do not think he will claim any of the Quebec group when he becomes satisfied that it all lies above the Potsdam.—E. B.

River forms; but fortunately several of them are silicified; and when perfect specimens are worked out of the limestone-matrix, by the application of acid, they are found to differ, not a great deal, it is true, but, to such an extent that many naturalists would pronounce them to be distinct from those of the two formations mentioned. All the genera of trilobites that have been found in the Trenton, except *Acidaspis*, *Bronteus*, *Calymene*, and *Encrinurus*, occur in the Quebec group. On the other hand we find all the Potsdam and Taconic genera, except *Atops*, *Bathynotus*, and *Aglaspis*. Along with these there are several new genera of trilobites and some European types, such as *Ampyx*, *Nileus*, *Holometopus* and *Æglina*, not yet known as occurring in the north-western portion of the palæozoic basin of America.

We have thus in the Quebec group, that intermingling of the types, of the first and second faunæ, that must be expected in a formation whose true position is low down in the Silurian series and near the primordial zone. And as the species properly belonging to the second fauna, are vastly in the majority, we have assigned to the formation a position a little above the Potsdam group.

Such being, in substance, the general conclusion that has been arrived at, *i. e.* that the Quebec group is situated in the lower half of the lower Silurian, it is next to be shewn, to which of the American sub-groups it can be paralleled. And here we must, perhaps, make some allowance for the existence of zoological provinces in the Silurian seas, similar to those of the present day. If a line be drawn following the St. Lawrence from its mouth to the neighbourhood of Quebec, thence to the northern extremity of Lake Champlain and then along the lake to Whitehall; thence to Albany and along the Appalachians to Tennessee, I think it will be found, that the palæozoic rocks lying south-east of that line contain some groups of fossils, to a great extent specifically distinct from those imbedded in rocks of the same age lying north-west of it. In this way we may in part, but not altogether, account for the extraordinary fact of the Quebec group yielding such a large number of species distinct from those occurring in New York and Canada west.

Or, it might be explained, by supposing that in the south-eastern region, there are deposits which do not exist in the north-west. The thickness of the Calciferous and Chazy in Canada west of the line, cannot be much over 600 feet, while the Quebec group is at least 6000. In Pennsylvania, Prof. Rogers says, his Auroral series,—supposed by him (and correctly too I believe) to represent the calciferous Chazy and Black River,—is from 2500 to 5500 feet thick. It is thus very clear that, either the same strata must be greatly thicker in the south-eastern region than they are in the north-western, or else that the whole formation is swollen by additional deposits. Perhaps both of these reasons should be taken into account.

In 1859 I made an examination of all the Calciferous and Chazy fossils, in the Provincial Museum, and found that there were 41 species in the former and 129 in the latter, but not one species was clearly identified as common to the two formations. I believe that between the Calciferous and Chazy, as developed west of the line, in Canada, there is an almost total break in the succession of life. There are few geologists who believe in periodic extinctions of all animal life extending over the whole earth. It is almost certain, that gaps of this kind are mere local phenomena.

And if so,then somewhere else strata will sooner or later be found, holding a fauna composed partly of species occurring in the beds below and partly of those found in beds above the gap, thus connecting the two formations. I think it probable that a large portion of the Quebec group is of an age between the Calciferous and Chazy. But I do not believe that this would be sufficient to account for so great a number of species distinct from those of these two formations. The existence of zoological provinces in the Silurian seas, although not yet clearly proved, is something that should always be kept in mind, while endeavouring to work out a problem such as that presented by the fauna of the Quebec group.

Of the 129 species of the Chazy limestone, twenty-one pass upwards into the overlying formations. In the Black River limestone, lying just on the top of the Chazy, we find a sudden and great increase in the number of species. Nearly all of these pass upwards into the Trenton and many of them into the Hudson River. There is here another break (between the Chazy and Black River) but not so decided as that between the Calciferous and Chazy. When we find (as in the instance of the Black River and Trenton Fauna) a sudden appearance of a vast number of new species, we must suppose either that all these new species were suddenly created at the time the beds, in which we first find them, were deposited; or, that previous to the deposition of these beds, they lived in some other tract of the ocean. I am inclined to believe in the latter view. In the Quebec group, in Newfoundland, we find in beds lying below those holding *Bathyurus Saffordi* and the compound graptolites, several species which can scarcely be distinguished from well known Black River and Trenton forms. They are all a little different, but still so closely allied that I am greatly at a loss to decide whether or not they should receive new names. This can only be settled by first deciding the question of the difference between varieties and true species. The fossils in question are either identical with, or are varieties of the following species: *Murchisonia gracilis*, *M. bellicincta*, *M. bicincta*, *Orthoceras Allumettense*, and *O. Bigsbyi*,(the latter *Ormoceras tenuifilum* of Hall). The first three of these species are, as is well known, common in the Black River and Trenton; *O. Allumettense* occurs both in the Chazy and Black River, but has not yet been found in the Trenton, while *O. Bigsbyi* seems to be confined to the Black River. I think these species lived in the south-eastern region during the period of the deposition of the Quebec group, and (either they or their modified descendants) migrated north-westerly during the Chazy and Black River periods.

If we compare the whole fauna of the Quebec group with that of the Black River and Trenton, we shall find that the two cannot be identified at all upon any known principle of zoology. The difference cannot be explained away by the theory of distinct zoological provinces, because there are places (such as at Montmorency) where the Trenton limestone, crowded with its own species can be seen lying in horizontal strata, while just across the channel which separates that locality from the Island of Orleans, (almost within gunshot) the enormous mass of the Quebec group with its compound graptolites and mixed fauna of primordial and silurian trilobites is grandly displayed. It is impossible that two faunæ, totally different could live for ages within a mile of each other in the ocean, without any barrier between them, and retain their distinctive characters.

There is none of the true Chazy and Calciferous in the neighbourhood of Quebec. But at Highgate Springs, near Phillipsburgh, at the northern extremity of lake Champlain, there is an exposure of the Chazy, Black River and Trenton limestones. The two latter formations can be easly identified by their fossils and lithological characters, but the beds supposed to represent the Chazy consist of sandstone shales and nodular limestones, and differ somewhat from the formations elsewhere, and besides are almost destitute of fossils. They certainly underlie the Black River. The only species identified in these beds are *Ptilodictya fenestrata*, *Orthis platys* and *Ampyx Halli*. The first two of these are good Chazy species, in the typical localities, but the last is not; and I may mention here that no species of *Ampyx* has yet been found in the north-western region of our palæozoic basin, but I know of four or five in the south-eastern; all, either in the Chazy, or in the Quebec group, except one at Gaspé, which occurs in slates the age of which is not determined. One of the species occurs in Tennessee in the upper strata of Safford's formation 3 (most probably Chazy), and the others at various places in Vermont, Canada East and Newfoundland. The distance from Highgate Springs, in a straight line, to the village of Chazy the typical locality of the formation, is about seventeen miles in a westerly direction. Chazy limestone is said to occur on Isle La Motte, in Lake Champlain about twelve miles south-west of Highgate Springs. It would require a great deal of further examination of the locality at Highgate Springs in order to determine positively whether the true Chazy exists there, and if it do, what is the difference, in the grouping of the fossils between that and the typical locality, that might be due to geographical distribution.

Within two miles east of the exposure of Trenton and Black River limestone at Highgate Springs, we come to a large tract of limestone, of the Quebec group, which extends north to Bedford, a distance of about ten miles with a width of two miles at Phillipsburgh. A great many fossils occur in this tract of limestone, but not one of them has yet been identified as a Black River or Trenton form, and yet these two formations with a considerable number of their peculiar and characteristic species are exposed within two miles. Here then, as at Quebec, the theory of distinct zoological provinces will not explain the difference between the fauna of the Quebec group, and that of the Trenton and Black River.

The above is intended to show, that the Quebec group is not of the age of the Trenton, and that its upper limit cannot be higher than the base of the Black River. It is useless to compare it with the Hudson River, or any other higher formation. I think, however, that it must come very near the Black River, and, in describing the new species from Phillipsburgh, I have (in giving the locality and formation at the end of each description) referred them either to the "*upper part of the Calciferous formation*," or to "*beds holding fossils approaching in aspect to those of the Chazy or Black River formations.*"

The upper limits of the Quebec group, having been determined as above, it remains next to show how far it extends downwards. On this point I have only to say, that in Newfoundland, Mr. Richardson has discovered a series of rocks, which I have not the least hesitation whatever, in pronouncing to be positively identical in age with both the Loint Lévis and Phillipsburgh limestones. He has also ascertained, by a good coast section, that they clearly overlie all that part of the Calciferous which holds the remarkable and characteristic cephalopods of Mr. Salter's new genus *Piloceras.* These beds in their turn overlie conformably the sandstones holding *Lingula acuminata*, which characterizes the upper strata of the Potsdam, in Canada West, New York, and Wisconsin. We thus have two horizons well determined, between which the Quebec group (or at least that portion of it to which the Point Lévis and Phillipsburgh limestones belong) must be situated. The lower horizon is about the middle of the Calciferous, and the upper near the base of the Black River limestone.*

It follows from what has been above stated, that the Chazy limestone occupies a position between the same two horizons which limit the Quebec group above and below. Are these two formations *i.e.*, the Chazy and the Quebec group, of the same age? On this point all that can be said is that the Quebec group holds about 300 species of fossils (including the graptolites), and I cannot identify a dozen of them with true Chazy species. My own view is, that in a portion of the Quebec group, we have a set of strata representing those which are absent in Canada, west of the line where the break occurs between the Calciferous and Chazy formations. The remainder may possibly be of the age of the Chazy, the difference in the species being due to geographical distribution. I only offer this however as a possible solution of one of the difficulties that have been met with, in endeavouring to arrive at the truth, in this complicated question.

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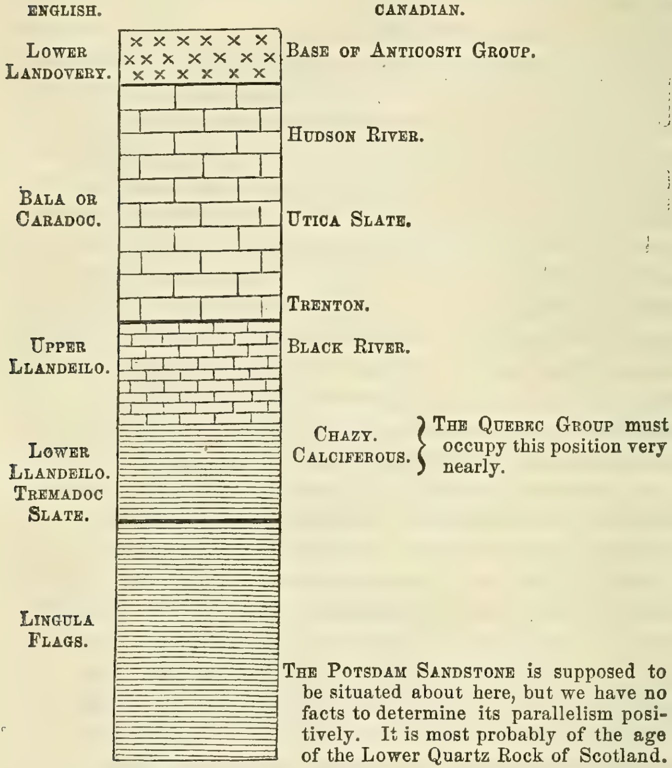
* It is possible that the lower part of the true Calciferous may be represented by some of the slates in the south-eastern region in which no fossils have yet been found.

Diagram Shewing the supposed Parallelism of the English and Canadian Lower Silurian formations.



The Quebec Group must occupy this position very nearly.

The Potsdam Sandstone is supposed to be situated about here, but we have no facts to determine its parallelism positively. It is most probably of the age of the Lower Quartz Rock of Scotland.

Below the Lingula Flags in England are situated the Cambrian (Sedgwick), beneath which the Laurentian (Logan) occurs in the North of Scotland.

In Canada, we have below the Potsdam, the Huronian (Logan), and beneath that, the Laurentian.

In England the Potsdam formation has not I believe been clearly identified; but in Scotland, Sir R. I. Murchison has shewn in several papers, published in the Journal of the Geological Society, that it is represented by the Lower Quartz Rock of Sutherlandshire. It is there overlaid by the Durness limestone, which has been identified by him and by Mr. Salter as of the age of the Calciferous formation. I have seen the fossils collected by them, and think that their opinion is undoubtedly correct. In Canada, the Quebec group with its compound graptolites, overlies all those rocks which represent the Durness limestone.

The Black River and Trenton limestones, the Utica slate and Hudson River of Canada, represent the upper half of the Lower Silurian of England, but the sub-divisions recognized in the two countries cannot be exactly paralleled. It is almost certain that the Hudson River represents a portion of the Bala or Caradoc. I think that the Trenton limestone might well be paralleled with the base of the same group. The Black River may be nearly parallel with a part of the Bala and the highest strata of the Upper Llandeilo.

I shall now notice briefly Mr. Marcou's last publication,[*] in which the following section is given in descending order:

1. Potsdam Sandstone	300	feet.
2. Quebec Group	2,400	"
3. Point Lévis Group	1,000	"
4. Gilmour Group	400	"
5. Chaudière Group	3,000	"

No facts either physical or palæontological are given by Mr. Marcou in support of the above classification. It is purely conjectural. He places the limestones and slates of Point Lévis and Phillipsburgh, which have yielded nearly all the fossils of the Quebec group yet discovered, in what he calls the Point Lévis and Gilmour groups, the highest beds of which are according to his section 2400 feet below the base of the Potsdam sandstone. From these rocks we have in the Provincial Geological Museum at Montreal the following genera of organic remains:

GENERA OF THE QUEBEC GROUP.

Eospongia, *Stenopora*, *Tetradium*, *Petraia*, *Rhodocrinus*, *Glypocrinus*, *Palæocystites*, *Dictyonema*, *Graptolithus*,[†] *Obolus*, *Obolella*, *Lingula*, *Acrotreta*, *Leptæna*, *Strophomena*, *Camerella*, *Rhynchonella*, *Cyrtodonta*, *Holopea*, *Subulites*, *Murchisonia*, *Eunema*, *Pleurotomaria*, *Helicotoma*, *Ophileta*, *Maclurea*, *Ecculiomphalus*, *Metoptoma*, *Bellerophon*, *Orthoceras*, *Cyrtoceras*, *Lituites*, *Nautilus*, *Æglina*, *Agnostus*, *Amphion*, *Ampyx*, *Arionel-*

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[*] *Letter to Mr. Joachim Barrande, on the Taconic Rocks of Vermont and Canada*; by Jules Marcou, Cambridge, Massachusetts, August, 1862.

[†] There are several sub-genera of *Graptolithus*, but as the Decade in which they are to be described is not yet published, I am unable to name them with certainty.

lus ? Asaphus, *Bathyurus*, *Cheirurus*, *Conocephalites ? Dikelocephalus*, *Endymion*, *Harpides*, *Holometopus*, *Illænus*, *Leperditia*, *Lichas*, *Menocephalus*, *Nileus*, *Olenellus*, and *Shumardia*.

Any one who has studied the palæontology of the older rocks will perceive that the above is a Silurian fauna. Out of fifty-three genera there are only seven which have a primordial aspect. They are the following:

Agnostus,
Arionellus,
Bathyurus,
Conocephalites,
Dikelocephalus,
Menocephalus,
Olenellus.

These seven genera are just sufficient to give to so large a fauna a perceptible primordial tinge, so to speak, indicating a proximity to the base of the Lower Silurian. Of the species there are ten or twelve considered to be identical with well known Calciferous and Chazy forms; and about as many more which are closely allied to some of those occurring in these and some of the overlying formations. I have marked the genera *Arionellus* and *Conocephalites* doubtful, as it is not quite certain that *A. cylindricus*, *A. Sedgwicki*, and *C. Zenkeri** are sufficiently determined. It makes little difference however, as the species have a primordial aspect.

There is no palæontologist in America who will ever believe that we have in Canada a formation lying 2400 feet below the base of the Potsdam, holding a fauna composed of the genera given in the above list. No English palæontologist will believe that such a fauna is to be found in rocks older than the Lingula flags. Barrande will certainly not admit such a fauna into his Primordial Zone. Dr. Emmons will not take the Point Lévis and Phillipsburgh limestones into his Taconic system. In several letters which I received from him in 1860 after the first publication of the Quebec fossils, he says that he considers the Point Lévis limestone to be the Lower Silurian and of the same age nearly as the limestone of Troy, Bald Mountain, Mount Toby and other places in New York. But he seems to claim the slates which hold the graptolites. Barrande, however, both in his published papers and in his letters to me, steadily refuses to admit the graptolites into the primordial zone. Sir R. I. Murchison also maintains with Barrande that all graptolitic rocks are Silurian.

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* This species may belong to the genus *Harpides*.

As the Point Lévis and Phillipsburgh limestones are thus turned out of the Taconic system by Emmons, and the graptolitic rocks of the same localities refused admission into the primordial zone by Barrande, Mr. Marcou will experience much difficulty in maintaining his classification.

Apparently in anticipation of this difficulty, he says, that the limestones in question, are centres of creation, and that the fossils are groups of Lower Silurian types which made their appearance in the ocean during the primordial period. They are thus Silurian colonies in the primordial zone. But he does not give any facts in proof of this theory. He seems to ignore the inflexible rule to which every investigator must submit, that he who advances a new proposition in science, must furnish the public with the proof. He has the affirmative side of the question, and the *onus probandi* lies upon him. Thus, in endeavouring to point out the geological age of the Quebec group, we laid our proofs before the scientific world; we published our facts. Every fossil species described and figured, is a natural fact, upon which a scientific man may reason, and from which he can draw conclusions. The first step Mr. Marcou must take, in order to establish his classification, is to prove that the slates, in which the lenticular masses of limestones holding his colonies are imbedded, belong to the primordial zone. He can only do this, by palæontology, or, by physical geology. A vast proportion of these slates hold no fossils at all, or at least, none have been found in them; and therefore their age cannot be determined by palæontology. The remaining portion do, it is true, hold fossils, but they are not primordial; they are all either Lower Silurian types, or such as are common to the first and second faunæ. In addition to the graptolites we have *Obolella desiderata*, *Lingula Irene*, *L. Quebecensis*, *Orthis*, (two species one of which seems to be *O. electra*, and the other *O. gemmicula*, *Strophomena*, (1 species) *Shumardia granulosa*, and a new species of *Asaphus* with a ribbed pygidium like that of *A. Canadensis*. There are as I am informed between forty and fifty species of graptolites belonging to several genera. I have also a specimen of an obscure fossil which may be a *Tetradium*. According to palæontology this group of fossils belongs to the second fauna, and is not primordial. It furnishes therefore a point-blank contradiction to Mr. Marcou's classification. It must be borne in mind, that these slates, are not of the same age as those of Georgia in Vermont, which are characterised by the presence of the trilobites *Olenellus Vermontana*, *O. Thompsoni*, &c. These latter are primordial and belong to the Potsdam group. They may very properly be placed in the Taconic system, but they lie far below the Quebec group.

As Mr. Marcou can derive no aid from palæontology in support of his classification, he must establish it by physical geology. He must point out some place where the Potsdam can be seen overlying the Quebec group, as represented in his section. The locality must exhibit the rocks in their natural position. There must be no disturbances, such as faults and overturns. Now, at Quebec, not only are the strata wonderfully contorted and faulted, but further, Mr. Marcou says he could not find any Potsdam there at all. He says on page 13 of his published letter to Barrande :

> "The Potsdam Sandstone does not exist in the district of Quebec, and I did not see a single trace of it north of the Grand Trunk Railroad from Richmond to Montreal. Probably if these rocks were ever deposited in that region, not finding any point of resistance close by, as in the Adirondack country, *they slipped under all the other strata in the overturn of the Taconic*, and have been entirely concealed from view by the succeeding groups."

If the Potsdam be concealed from view at Quebec, how does he know that it overlies the Quebec group? In the above quotation I have italicised a few words, because at p. 10 he informs Barrande that the strata at Point Lévis are not much disturbed, "and that the few foldings in the strata of the Ferry Cliff, are mere accidents, confined to a distance of a few feet, and are without any effect upon the whole mass of strata, but are, what we call in French, *structure ployée* (contorted beds). This does not agree very well with the asserted overturn. According to my view, when a huge formation of rock, more than a mile in thickness, and occupying many thousand square miles in geographical extent, has been turned completely upside down (as Mr. Marcou says his new Taconic system has been) by some tremendous convulsion of nature, the structure must indicate a very considerable amount of disturbance.

Passing now from Quebec to Phillipsburgh and Swanton, Mr. Marcou, has given us another section to indicate the succession at these two latter localities. It is as follows in descending order :

1. POTSDAM SANDSTONE,...............	300 feet.
2. SWANTON SLATES,..................	2000 "
3. PHILLIPSBURGH GROUP,..............	1300 "
4. GEORGIA SLATES,....................	400 "
5. ST. ALBAN'S GROUP,................	3000 "

No. 4 of this group is primordial, but No. 5, the St. Albans' group, is very obscurely, or not sufficiently defined, to enable us to recognize it. No. 3 consists of a large tract of stratified limestone ten miles in length, and (opposite Phillipsburgh) two miles wide. The strata, in general, dip easterly at an angle of from 12° to 25°, but in many places the dip is much steeper and in a different direction. It is not an accumulation of lenticular masses, as Mr. Marcou calls it, but a large tract of regularly stratified limestone. Its thickness, measured across the outcropping edges of the strata, is about 1500 feet. It holds numerous fossils, mostly identical with those of the Point Lévis limestones. The slates called by Mr. Marcou Swanton slates., and placed, in his section, above the limestones and below the Potsdam, are, in great part, destitute of fossils. A few graptolites have been found in them by the Rev. Mr. Perry, Dr. Hall (both of Swanton), and myself. They are thus, according to palæontology, not primordial slates. Here then, as at Quebec, palæontology affords Mr. Marcou no assistance, but strong opposition instead. Physical geology does not aid him in placing the Potsdam above the slates because neither at Phillipsburgh nor at Swanton is there any of the Potsdam within a mile of them. How then does he know which of the two formations is uppermost? The only place where these slates can be seen in this neighbourhood, in contact with any other formation, is at the village of Phillipsburgh, and here they underlie the limestones. They form the lower thirty feet of the cliff along the water's edge, commencing at Strite's Hotel. Yet Mr. Marcou places them above the limestones. If he is right, then there must be a great dislocation here.

Mr. Marcou says, that last year, he remained only a few hours at Phillipsburgh and that he adopted, without examination, the opinions expressed by me in my paper on the age of the Phillipsburgh limestones, referring them to the Calciferous and Chazy. "But, he says, "a careful survey this year has convinced me that at Philipsburgh, as well as at point Lévis, Mr. Billings has been misled in giving explanations, and arriving at conclusions, in his palæontological researches, which are *entirely at variance with what exists in nature*." In answer to this I shall only say that I studied the natural facts that were laid before me, *i. e.*, the fossils, according to the principles established by the great masters of palæontology, such as Cuvier, Barrande, Agassiz, and others; and I do not fear for the result. If he had done the same he never would have placed the Quebec group below the Potsdam. As he has published and circulated a letter addressed to Barrande, containing the above remarks, he is bound, in honor, to publish Barrande's answer, and circulate that also. If he do not, then we must believe that Barrande does not coincide with him.

From Pillipsburgh, a range of exposures of limestone, runs southerly to St Albans Bay in Vermont, a distance of about twenty miles. Some of these small tracts of limestone are Trenton, while others may belong to the Quebec group. At St. Albans Bay there is a cliff or ridge, of reddish magnesian limestone and sandstone, running north and south, nearly parallel to, and a short distance from the shore. This I believe to be the Potsdam. A road, from the town of St. Albans down to the Bay, crosses this ridge at a right angle, passing through a wide irregular ravine. North of the road there is an exposure of greyish or whitish limestone at the foot of the cliff, which may belong to the Quebec group. It seems to plunge under the sandstone, as it is exposed within ten feet of it and dips towards it. In this limestone I found a *Pleurotomaria* very like one that occurs in the Quebec group. This place, might be appealed to as affording proof, that the Potsdam overlies the Quebec group physically. But I think there is a dislocation here. The Potsdam dips easterly at a gentle angle, but the limestone is greatly disturbed, and is in some places vertical. Again, following the base of the cliff southerly across the road we soon come to another exposure of limestone of a different age. It is dark grey, blue and black and often traversed by seams of white calc-spar. The stratification is much confused, thus indicating the promixity of a fault. Some of the beds hold *Stenopora fibrosa*, *Strophomena alternata* and *Asaphus platycephalus.* These are either Trenton or Black River. In one place the weathered surfaces exhibit sections of *Pleurotomaria* and *Maclurea* and may be Chazy. It seems to be underlaid by a black slate. The rocks of this exposure also seem to plunge under the Potsdam, as do those north of the road.

The Potsdam at St. Albans Bay thus comes in contact with two different formations, within a distance of half a mile. According to Mr. Marcou's section there ought to be here 2000 feet of slate between the limestone and Potsdam. I think that all the facts, both palæontological and physical, that can be observed here, indicate the existence of a great fault, with an upthrow on the eastern side.

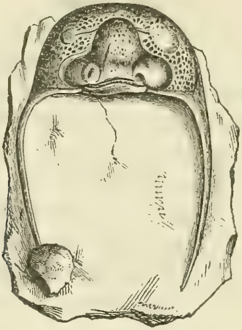
About twenty-five miles further south, at the small promontory called Sharp-shins, or Lone-rock Point, at Burlington, a formation of limestone, which appears to belong to the Potsdam, is seen resting on black slate, the contact being visible. In the debris of broken slate, at the foot of this cliff, the Rev. Mr. Perry found some imperfect fossils. Among these I recognized a fragment of *Conularia*, and the punctured border of the head of a *Trinucleus*, As the fossils were found loose, the age of the slates is not determined palæontologically. But I have shown (Am. Jour. Sci., 2d Sep., Vol. 33, p. 102) that the underside of the limestone, or the surface of it which is in contact with the slate, is smoothed, and presents very much the appearance of slickensides. There are thus at this place also indications of a dislocation.

At Buck mountain, still further south in Vermont, I have also shown (Soc. Cit., p. 103) that the Potsdam is brought up by a fault (with an upthrow on the east side) against the Chazy and Black River. I think the limestone at the north end of this mountain belongs to the Quebec group.

At Snake mountain, about a mile further south, the Potsdam has about 700 feet of black slate below it. But as the undoubted Chazy limestone is seen at the foot of the hill, apparently plunging under the slate which supports the Potsdam, there must inevitably be here (as Dr. Emmons has long held) one or more great faults. No fossils have been found in the slates at this locality, *i.e.*, in those that have the Potsdam above them.

All the evidence, both physical and palæontological, thus far collected, seems to show that (in the disturbed region of the south-eastern portion of the palæozoic basin of North America) *whenever the Potsdam, with its primordial fauna, appears to overlie rocks holding the types of the second fauna*, there will be found some evidence of a great fault, often with an overlap, by which the older rocks are not only brought up to a level with the newer, but even shoved over them. This solution of the great problem, which for twenty years has been so much discussed by American geologists was first brought out by Sir W. E. Logan, in Dec., 1860, and all the new facts ascertained since then, along the line of the fault, prove that it is the only true one that has yet been advanced.

Description of a new species of Harpes from the Trenton Limestone, Ottawa.



HARPES DENTONI. (N. SP.)

(The glabella is distorted in the posterior half.)

Description :—The head of this species, exclusive of the posterior prolongation of the border, is nearly semi-circular. The border itself is not wholly preserved in the specimen, so that its width cannot be ascertained. The length of the head without the border is six lines, and its width on a line running across the neck segment one inch. The margin is prolonged backwards thirteen lines from the neck furrow. The head is rather strongly convex, its elevation at about mid-length of the glabella being about four lines in the specimen, although a little depressed by distortion. The glabella is strongly convex being elevated nearly one line above the level of the cheeks; it is obtusely rounded in front, and appears to be nearly as broad where a line drawn through the eyes crosses it as it is at the neck furrow, but on this point there is some doubt as the posterior portion is crushed. The neck furrow is well defined across the glabella, and curves a little forward on the median line. The neck segment is well developed. On each side of the base of the glabella, there is an irregularly semi-oval space, the outer margin of which, is abruptly sunk about half a line below the general surface of the cheeks. This space is bordered on its posterior margin by the neck furrow;—on the outer and anterior side, by a nearly vertical elevation of the crust of the cheek, the outline of the space making an obtusely rounded curve on the outside and then turning inward and forwards to the glabella, which it reaches at an acute angle on a line crossing the eyes. There appears to be slightly impressed glabellar furrow on each side, which commences at about one line from the neck furrow, at about one third the width of the glabella from the side of the same, and runs obliquely forwards and outwards, reaching the side at about one line behind the eye. In front of this, there appear to be, two small depressions in the side of the glabella close to the surface of the cheek and opposite the eye. A line drawn across the head through the eyes would cross the glabella at about one third its length from the front. The eyes are small tubercles, scarcely half a line in diameter, and situated about two lines from the side of the glabella. A small thread like ocular ridge runs from the eye forward, nearly to the front of the glabella, but does not appear to cross the small dorsal furrow which runs round the sides and front. The neck segment forms a vertical elevation along the the posterior margin of the head, half a line in height and curving backwards gradually passes into the posterior prolongations of the head. These as far as they can be seen are nearly vertical, but sloping a little inwards and upwards.

The surface of the whole head is covered with small irregularly polygonal pits separated from each other by sharp edged walls. On the cheeks these pits are on an average about one fourth of a line across, but they vary in size, some of them being much smaller than the others. They seem to be in general a little smaller on the glabella than on the cheeks. Where a portion of the crust is broken away, from the front of the head, a cast of the inner surface can be observed. It is covered with small round tubercles, about three in one line.

This species differs from *Harpes antiquatus*, the only species hitherto described from the Lower Silurian Rocks of Canada, in having the glabella more obtusely rounded in front, and in the remarkable characters of the surface which is reticulated, all over the head, by the sharp lines separating the angular puncture, while in *H. antiquatus* the glabella is smooth or only minutely punctured.

Dedicated to Mr. William Denton, of Painesville, Ohio, who discovered it.

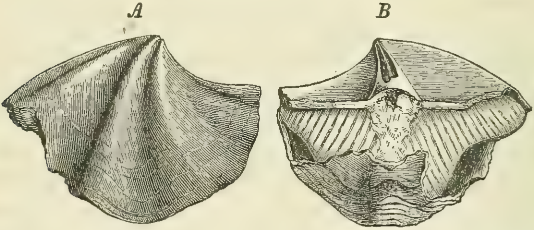
Locality and Formation.—Ottawa, Trenton limestone.

On the Internal Spiral Coils of the Genus Cyrtina.

Mr. Davidson, in his monograph on the British Carboniferous

Brachiopoda, p. 68, points out, that no spiral coils had been noticed in the genus *Cyrtina* by any author. By working at some silicified specimens with acid, I have been so fortunate as to discover these organs in two species. Their position is the same as in *Spirifera*, but the first two coils are (at least in one of the species, *C. Dalmani*, Hall) connected a little in front of the mid-length by an apparatus somewhat like that of *Spirigera*, but not so complicated. A very slender process springs upwards towards the ventral valve, from each coil, and at the height of about one line, curves forwards. The two then unite, and form a single band, which extends forwards to about the front of the coil, and there ends in an obtuse point. This connecting process I have only seen in one specimen of *C. Dalmani*. The other species appears to be new, and I shall describe it under the name of

CYRTINA EUPHEMIA. (N. SP.)



Cyrtina Euphemia, (N. sp.) *A*, ventral view, *B*, dorsal view, shewing the area and spiral coils.

Description.—Shell rather large; ventral valve moderately convex, irregularly depressed pyramidal, sub-semi-circular, the margin undulated in its outline by the large radiating folds; mesial sinus commencing in a point at the beak, and gradually enlarging so that its width at the front margin is equal to nearly one third the whole width of the shell at the hinge line. On each side of the mesial sinus, a single large rounded rib or fold, nearly equal to the width of the sinus, becoming angular near the beak. Near the cardinal edges there are two other obscure depressed convex folds, one on each side. Area concave, at right angles to the plane of the margin in the lower third, but incurved in the upper two thirds. Beak minute, pointed and incurved a little over the cardinal edge. Foramen narrow, its width at the hinge line equal to half the height of the area, closed by a thin convex deltidium in the lower half; in the upper half, open and shewing, within, the thin plate which partially divides the triangular chamber of the ventral valve. In the only specimen collected, the beak and area are distorted being turned to the left. This is not the result of pressure, but owing to an irregularity in the growth of the shell.

Dorsal valve moderately convex with a large rounded mesial fold, and two others obscurely developed, one on each side.

Surface not well preserved in the specimen, but apparently smooth with some lamellose lines of growth. In one specimen the shell appears to have an inner coarsely punctate layer.

The spires at their bases, or where the two cones abut against each other, base to base, extend from the hinge line to the front margin, but they rapidly diminish in diameter outwards and become sub-cylindrical near the cardinal angles.

The specimen when perfect must have been at least 18 lines wide on the hinge line; length of dorsal valve 8 lines; length of ventral valve from the beak to the front margin 12 lines; height of area about 6 lines, width of foramen on the hinge line 3 lines.

Along the edge of the open part of the foramen, there are some indications that the deltidium, when perfect, extended nearly to the beak.

Locality and Formation.—Township of Walpole, Canada West; Corniferous limestone, Collected by J. De Cew.

ART. IV.—*On a new method of preparing Chlorine, Carbonate of Soda, Sulphuric Acid and Hydrochloric Acid;* by THOMAS MACFARLANE.

In a former paper * I had occasion to describe the nature of the reactions which take place on calcining iron pyrites with a small proportion of common salt. These reactions I supposed to be as follows :—First, the greater part of the sulphur of the pyrites is oxidized by the air, and disengaged as sulphurous acid, the iron also combining with oxygen and forming peroxide of iron. At a later stage of the operation, part of the sulphurous acid formed comes in contact with the peroxide of iron, and is through its agency further oxidized into sulphuric acid, which combines with the iron oxide, forming finally a comparatively small quantity of sulphate of peroxide of iron. This salt reacts on the chloride of sodium, producing sulphate of soda and perchloride of iron. Air having still access, the perchloride of iron is resolved into peroxide of iron and chlorine gas, which latter escapes, and may be recognized by its odor as soon as the evolution of sulphurous acid has ceased. Assuming this explanation to be correct, it occurred to me that chlorine might be produced on a large scale by taking advantage of the reactions which occur towards the end of the process above described, and by substituting common green vitriol (calcined) for the sulphate of peroxide of iron formed by the reactions just mentioned.

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* Canadian Naturalist for 1862, p. 194.

I found however on calcining a mixture of four parts of calcined green vitriol (the formula of which may be regarded as $Fe_2\ O_3$, $2\ SO^3$) and three parts of common salt, in a muffle furnace, at a moderate red heat, that these substances fused together, and evolved, instead of pure chlorine, a mixture of this gas with vapors of perchloride of iron. I then prepared perchloride of iron by heating together calcined green vitriol and chloride of calcium over a spirit-lamp. In this reaction the materials did not fuse together, and the perchloride of iron sublimed from the mixture was decomposed at a gentle heat in the muffle into chlorine and peroxide of iron. It was also decomposed when heated with peroxide of manganese over a spirit-lamp, pure chlorine being evolved. On heating a mixture of calcined green vitriol and common salt in the same way, it fused, but gave no sublimate, nor was there any chlorine evolved on heating the same mixture with peroxide of manganese. On the other hand, a mixture of calcined green vitriol, chloride of calcium, and peroxide of manganese heated over a spirit-lamp did not fuse nor agglutinate, and gave off chlorine abundantly. From these experiments it seemed essential in order to the production of chlorine from calcined green vitriol and common salt, that these materials should be kept in a loose and porous condition, in which state the oxygen of the atmosphere might more readily permeate the mass. I accordingly added to the mixture of four parts of calcined green vitriol and three parts of common salt, an equal weight of peroxide of iron, and heated the mixture in the muffle. The fusion of the materials was thus prevented, and an abundant evolution of pure chlorine took place. On continuing the calcination until chlorine was no longer evolved, I found that the residue consisted almost exclusively of sulphate of soda and peroxide of iron. The solution obtained by treating it with hot water contained no iron. I then took 474 grains (3 equivalents) of calcined green vitriol, 351 grains (6 eq.)

of common salt, and 702 grains (9 eq.) of peroxide of iron (a lesser proportion than in the former experiment), mixed them intimately and introduced them into a glass flask, heated by a spirit-lamp. By means of an aspirator of caoutchouc, I drew a current of air, not previously dried, over the heated mixture, and then successively through water, dry hydrate of lime, and a solution of caustic potash. The latter at the close of the experiment gave with hydrochloric acid no odor of chlorine, but the hydrate of lime similarly treated evolved abundance of it, and indeed possessed all the properties of bleaching powder. The production of chlorine and bleaching powder was therefore in this case accomplished, but the large quantity of peroxide of iron remaining in the residue rendered this unfit for the further treatment required for the manufacture of carbonate of soda. I accordingly sought to reduce to a minimum, the quantity of peroxide of iron to be added to the other ingredients, and found that a mixture of 316 grains (2 eq.) of calcined green vitriol, 234 grains (4 eq.) of common salt, and 312 grains (4 eq.) of peroxide of iron was capable of being calcined under the muffle, at a low red heat without melting, and yielded pure chlorine. On continuing the calcination until no more of this gas was evolved, the residue contained in 100 parts :—

Peroxide of iron	65.9
Sulphate of soda	31.1
Chloride of sodium	3.0, by difference.
	100.0

Encouraged by this result, I diminished still further the quantity of peroxide of iron used, and the temperature employed during the calcination. 316 grains (2 eq.) of calcined green vitriol, 234 grains (4 eq.) of common salt, and 156 grains (= 2 eq.) of ferric oxide yielded chlorine ; on calcination in the muffle, and left a residue weighing 573 grains, and containing in 100 parts :—

Peroxide of iron	54.0
Sulphate of soda	42.1
Chloride of sodium	3.9, by difference.
	100.0

After this I performed two additional experiments with the following proportions of materials:—

	I.	II.
Calcined green vitriol	316	450
Common salt	234	351
Peroxide of iron	78	78

The muffle was kept at a faint red heat, and in both cases chlorine was abundantly evolved. Finally I found that it was even possible to calcine 316 parts of calcined green vitriol and 234 parts of common salt, without any admixture of peroxide of iron, and to obtain an abundant disengagement of chlorine. In this case however the muffle was not allowed to attain even the faintest redness. Even at this low temperature the materials sintered together slightly. I had thus by this series of experiments ascertained the exact conditions most favorable to the disengagement of chlorine from a mixture of calcined green vitriol and common salt, and proved that the explanation given above of the production of chlorine in calcining iron pyrites with common salt was the correct one. In the course of these experiments I was also led to expose chloride of manganese to a moderate red heat in the muffle, in presence of a current of air, as in the above trials. I found that that substance in an impure state, (prepared by evaporating to dryness the residue from the preparation of chlorine from peroxide of manganese and hydrochloric acid,) was in this way converted into an oxide of manganese of a higher degree of oxidation than the protoxide, with abundant disengagement of chlorine. The decomposition was easily effected, still it seemed as if peroxide of iron, or manganese, when mixed with the impure chloride of manganese, accelerated the evolution of the chlorine. The residue from the decomposition of the impure chloride of manganese, if exposed in the muffle until the evolution of chlorine was no longer observable, yielded chlorine when heated with hydrochloric acid, but none when heated with sulphuric acid. This last reaction proved that no undecomposed chloride of manganese was left in the calcined residue.

The residue from the production of chlorine from calcined green vitriol and common salt, consisting of a mixture of sulphate of soda and peroxide of iron, on being mixed with powdered coal or charcoal, and ignited, fuses readily, and the resulting product, when treated with water, affords an alkaline solution, colored green, by dissolved sulphuret of iron, and an insoluble residue, of finely divided sulphuret of iron. This alkaline solution when exposed to the influence of carbonic acid and oxygen, becomes decolorised, and yields on evaporation carbonate of soda. This method of producing soda was proposed as early as the year 1778, by Maleherbe, a Benedictine monk, who however used metallic iron instead of the peroxide; and is the same in principle as that patented in Great Britain, by Blythe and Kopp, in 1856. These patentees prevented the partial solution of the sulphuret of iron by the alkaline liquid, by exposing the melted material to the action of carbonic acid and atmospheric air previous to treating it with water. I have however found that in the simple evaporation of the solution the decolorisation is effected by a separation of the dissolved sulphuret. In carrying out the method on the large scale. the action of the readily fused alkaline mass on the usual furnace materials is found to be very severe. In the course of my experience in refining impure arseniurets of nickel and cobalt, on the large scale, by fusing these with sulphate of soda and charcoal, I ascertained that a furnace bottom consisting principally of ground quicklime, resists the action of the alkaline sulphurets, and I found on smelting the mixture of sulphate of soda, coal and iron oxide above mentioned, in contact with a hearth of the same material, that the latter was not acted on, and thus succeeded in removing one of the greatest practical difficulties which beset this new method of manufacturing soda.

The residual sulphuret of iron from the soda process, was according to Blythe and Kopp's patent, utilised by calcining it, and conducting the sulphurous acid thus produced into the leaden chamber, for conversion into sulphuric acid, in the usual manner. This moist sulphuret of iron, however, on being exposed to air and moisture, passes through various intermediate stages of oxidation, and finally becomes very rich in sulphate of iron. As this salt finds a ready and suitable application in the new method of producing chlorine, it seemed to me the preferable mode of recovering the sulphur, to remove the sulphate of iron from the oxidized mass by lixiviation, and to evaporate the solution obtained to crystallization.

Having thus stated the manner in which this new method of making chlorine and carbonate of soda suggested itself to me, I may be permitted to state, more concisely my manner of putting the method into practice, which is as follows:—828 parts of common crystallized green vitriol, (obtained either by the ordinary methods, or in the manner yet to be described,) are heated until they part with their water of crystallization, and become more or less oxidized, without however losing any sulphuric acid. The calcined green vitriol thus obtained is then mixed with 352 parts of common salt, (previously heated until it no longer decrepitates,) and also with 78 parts of peroxide of iron, (which may readily be obtained by calcining pure iron pyrites with five per cent. of common salt) and lixiviating the result. These ingredients, in fine powder, being intimately mixed, are introduced into a muffle calcining furnace, nearly of the same construction as that used in Europe for calcining arsenical pyrites. The mixture is spread over the hearth of the furnace, which is heated to faint redness by a fire placed underneath it. That part of the furnace over the hearth, which may be called the muffle, and to which the flames, or products of the combustion of the fuel have no access, is connected with an exhausting machine, which draws a current of air, (previously dried, by passing through quicklime), over the mixture which is spread out on the hearth of the furnace. A decomposition takes place at a very low temperature, between the sulphate of iron and the chloride of sodium, sulphate of soda resulting on the one hand, and protochloride and perchloride of iron on the other. The temperature in the furnace is so low that neither of the chlorides of iron is sublimed; but on the other hand the oxygen contained in the dry air passing over the mixture, converts both into peroxide of iron, which remains behind, and chlorine gas, which is drawn off by the exhausting machine. It is of the utmost importance in this operation, that the temperature be kept as low as possible, because anhydrous sulphate of iron and chloride of sodium heated together, to a higher temperature, fuse and emit fumes of perchloride of iron. In order therefore to obtain pure chlorine, the mixture must not be permitted to fuse, or even to sinter. The peroxide of iron in the mixture has some influence in preventing fusion, and in eliminating the chlorine. The greater the quantity of peroxide of iron used, the more easy it is to calcine the mixture without its caking together. I have not found it necessary however to use more than the proportion above stated, when the calcination is performed with proper care. During the operation, the materials are gently but frequently stirred with an iron rake; this also prevents sintering. I have found that in this operation thus conducted, the whole of the chlorine contained in the common salt is liberated in the gaseous state. By means of the exhausting apparatus, the chlorine, together with the nitrogen of the atmosphere, which is not absorbed by the mixture, is drawn, first through a layer of coke kept moist by water trickling over it, and then through lime slaked to a dry powder, somewhat in the same manner as common illuminating gas is passed through the dry lime purifier. The gases are freed by the water from any muriatic acid they may contain, and the chlorine is then quickly absorbed by the lime, and bleaching powder, or chloride of lime obtained. In the furnace there remains a residue consisting of about 427 parts of sulphate of soda and 312 parts peroxide of iron, which is withdrawn and treated in the manner about to be described. This production of chlorine and bleaching powder, and of a residue of sulphate of soda and peroxide of iron, may be called the first part of the new process.

This mixture of sulphate of soda and peroxide of iron is next mixed with 144 parts of powdered coal or charcoal, and is then introduced into a reverberatory furnace, the hearth of which has been previously prepared in the following manner: 100 parts of ground quicklime are mixed with 16 parts of basic slag, such as commonly produced in copper-smelting works, or of any other slag or glass not too difficult of fusion. This mixture is beaten into the bottom of the furnace, when in a dry state, the depression is then scooped out in it, and the tap-hole formed through it at the bottom, as is customary in preparing the hearths of furnaces intended for smelting. The furnace is now gradually heated up, and a strong heat continued, until the materials of the hearth have slightly caked together. As soon as this takes place a mixture of 100 parts of sulphate of soda and 25 parts of powdered coal or charcoal is introduced. This soon fuses and is totally absorbed by the hearth. More of the same mixture is then introduced, and this continued until no more of the resulting sulphuret of sodium is absorbed by the hearth. The furnace is then kept at a red heat, and is ready to receive the mixture of sulphate of soda, peroxide of iron and charcoal or coal already referred to. As soon as this mixture has entered into quiet fusion it is drawn off by the tap-hole into iron moulds or wheel-barrows, in which it solidifies, in large blocks. It is totally without corrosive action on the hearth; and an almost unlimited number of charges may be smelted down, without the hearth being at all affected. This on the contrary becomes and remains hard and compact, and can only with difficulty, be taken out of the furnace. These blocks of smelted material, which contain sulphur, sodium and iron, are immediately broken up, and introduced in a boiler exactly similar to that used for evaporating alkaline solutions in the ordinary method of manufacturing soda, in which the furnace is placed at one end, and the flame and products of combustion pass over the surface of the solution. On the introduction of the smelted material into the water, it is partially dissolved, and the solution assumes a deep greenish color, from dissolved sulphuret of iron. When however heat is applied, and the carbonic acid from the furnace produced in the combustion of the fuel, is passed over the surface of the solution, it is gradually decolorized, carbonic acid and oxygen being absorbed, and becomes a solution of carbonate of soda with caustic soda. In the event of the solution being too much evaporated before the decolorization is effected, water is added, and the heating and exposure to the carbonic acid and air continued. During the whole of this operation the insoluble sulphuret of iron remains at the bottom of the boiler. When the supernatant solution has become colorless, the heat is discontinued, and the contents of the boiler allowed to settle. The clear liquid is then drawn off by means of a syphon or stop-cock, and water is added to residue. If this solution also becomes green, it is decolorized in the same manner as the first. This second solution is then drawn off in the same manner, and the operation repeated with fresh water, until the latter dissolves no more soda from the residue. The first and more concentrated solutions thus obtained are evaporated to dryness, the product is heated in a carbonating furnace, and crystallized carbonate of soda and soda-ash obtained from it in the usual manner. The weaker solutions are used for treating fresh quantities of smelted material from the furnace. The sulphuret of iron which remains after having been thus repeatedy washed with fresh water-is run off from the bottom of the boiler into a large wooden box, having a perforated false bottom over which a linen cloth is spread. The greater part of the water here drains off and the sulphuret of iron is then fit to be treated in the manner next to be described. This production of carbonate of soda and of soda, ash may be termed the second part of the process.

The insoluble sulphuret of iron obtained as above described, while still in a moist state, is exposed, with as much surface as possible, to the action of the air and of moisture. It is placed on a perforated wooden floor covered with cloth, and supported over an impervious bottom of clay or other material, so inclined and arranged that the solution obtained in lixiviating the mass may be conveniently collected for further treatment. The moist sulphuret rapidly oxidizes, and passing through various intermediate stages of oxidation, it ultimately becomes very rich in sulphate of iron. It must never be allowed to oxidize so rapidly as to enter into combustion, because in that case sulphurous acid is produced, which would escape as gas, and be lost. This tendency to oxidize too rapidly may be counteracted by keeping the material moist. When a sufficient quantity of sulphate of iron has been formed in the mass, hot water is poured over the whole surface. This percolating through dissolves the sulphate, and falling on the impervious floor beneath, flows into channels prepared for it, and is finally collected in a large reservoir. The solution thus obtained is concentrated in boilers of the same description as those used in copperas works, and crystals of green vitriol are obtained in the manner usually adopted in the same establishments. The exposure and lixiviation of the sulphuret is continued and repeated until a residue is left consisting exclusively of peroxide of iron, and containing no sulphur. The green vitriol obtained as above described, is used in the first part of the soda process and the residue of peroxide of iron, if sufficiently pure, may also be used in that operation. This production of sulphate of iron, and of the residue of peroxide of iron, may be called the third and last part of the process.

Having thus to some extent described the new method of preparing chlorine and carbonate of soda, I proceed to advert to the advantages which it possesses over the ordinary process. The manufacture of bleaching powder and soda, as at present pursued, comprises the following operations; 1st. The manufacture of sulphuric acid from iron pyrites or sulphur, by the action of nitrous acid on the sulphurous acid and atmospheric air admitted into the leaden chamber, which nitrous acid is produced by the action of sulphuric acid on nitrate of soda; 2nd. The production of sulphate of soda and muriatic acid by the action of sulphuric acid on common salt; 3rd. The production of chlorine (and of bleaching powder,) by the action of muriatic acid upon the peroxide of manganese, in which process however only *one half of the chlorine* contained in the muriatic acid is evolved in the form of gas, the other half combining with manganese and forming with it a waste product of chloride of manganese ; 4th. The decomposition of sulphate of soda by igniting it with limestone and charcoal, in which operation the sulphur combines with lime, forming with it a waste product of sulphuret of calcium ; 5th. The extraction of carbonate of soda and soda-ash from the product of this ignition. With regard to these, the ordinary processes, the following facts are to be observed.—I. The whole of the sulphur contained in the sulphuric acid, and one half of the chlorine contained in the common salt originally used are lost. II. They comprise five distinct purposes, some of which, such as the manufacture of sulphuric acid, require very expensive apparatus. III. Nitrous acid, peroxide of manganese, and limestone are used in these process, in such a manner as not to be economically recovered, or only with great difficulty. In comparing these processes with the new method it will be observed : I. That by means of the latter the sulphur combined in the sulphuric acid of the green vitirol used in the first part of the process is recovered, and may be used an indefinite number of times ; and that *the whole of the chlorine* contained in the common salt is evolved as gas, and rendered available for the manufacture of bleaching powder. II. that the new method comprises only four processes, one less than by the ordinary mode, and that these do not require any extraordinarily expensive apparatus. III. That nitrous acid, peroxide of manganese, and limestone are altogether dispensed with ; only one material, peroxide of iron, being used in place of the limestone, but always in such a manner as to be recovered and used again. It will of course be evident that the advantages here enumerated result to some extent from the combination of what has above been termed the three different parts of the process. They form together an independent method for making bleaching powder and soda without the intervention or auxiliary manufacture of sulphuric and muriatic acids, or the necessity of using more than the one principal raw material, viz., common salt.

With regard to the new method of manufacturing sulphuric and muriatic acids, it is based upon the following chemical reaction—when sulphuric acid and chlorine gases in the proportion of their equivalents are brought in contact with water or steam, the oxygen of the latter unites with the sulphurous acid, forming sulphuric acid, while the hydrogen forms with the chlorine, muriatic acid. The manufacture of these acids on this principle was, in 1854, embodied in a patent for Great Britain, by William Hahner.* He however proposed to prepare the chlorine in the usual manner, from peroxide of maganese and muriatic acid, and mix it with sulphurous acid and steam in the leaden chamber. The mixture of sulphuric and muriatic acids here condensed, he proposed to treat by distillation, in order to separate the two. When it is considered that double the amount of muriatic acid produced in the process must be consumed in producing the necessary chlorine, the economy of the method seems exceedingly doubtful.

The mode I propose differs from that referred to above only in the method of preparing the chlorine, which is that already described in the beginning of this paper. By placing the usual furnaces for burning pyrites or sulphur, near the furnace for producing chlorine, as described in the first part of this paper, and connecting the exit pipes from these furnaces, with each other, and with a pipe from a steam-boiler, and drawing the gases thus mixed, either by means of an artificial draught, or an exhauster, through a condenser containing coke moistened with water, a mixture of sulphuric and muriatic acids would result. This mixture concentrated in leaden vessels, would yield sulphuric acid, while from the condensation of the vapors given off in this operation, muriatic acid would result.

Another method of preparing these acids is by calcining together 59 parts iron pyrites, 58½ parts of common salt, and 324 parts peroxide of iron. † Sulphurous acid is evolved at the commencement and chlorine towards the end of the calcination, in almost the proportions necessary for forming with water, sulphuric and muriatic acids. The residue consists of 336 parts of a mixture containing in 100 parts—

Peroxide of iron	79.5	
Sulphate of soda	19.2	=4.31 sulphur
Chloride of sodium	1.3	by difference
	100.	

This process should be carried on in two calcining furnaces, of the construction already mentioned in this paper. The second furnace should not be charged with the mixture of peroxide of iron, salt, and pyrites, until the charge in the first furnace begins to evolve chlorine, and by the time this has ceased the second furnace will have commenced to yield that gas, and the first furnace might be charged with new materials. Thus a continuous stream of chlorine and sulphurous acid would be kept up, and on mixing these with steam, and condensing them as above described, a mixture of sulphuric and muriatic acids would result, which is to be treated as above indicated.

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* Repertory of Patent Inventions, December, 1854.

† Vide Canadian Naturalist, p. 196.

Actonvale, Canada East. 16 February, 1863.

ART. V.—*On the Land and Fresh-water Mollusca of Lower Canada*; by J. F. WHITEAVES, F.G.S., &c.

(Read before the Natural History Society.)

PART I.—GENERAL CONSIDERATIONS.

Various papers of interest have appeared in the Canadian Naturalist, on the distribution of the land and fresh-water mollusca in Lower Canada. We are indebted to Messrs. Billings, Bell, and D'Urban, for nearly all the information we possess on this subject. Within the last two years new labourers have entered the field, and the result has been some addition to our knowledge of the geographical range of these creatures in Lower Canada.

My friend, Mr. R. J. Fowler has collected assiduously and successfully in the vicinity of Montreal, and in the Eastern Townships. In the summer of 1861 I paid special attention to the inland mollusca of the neighbourhood of Quebec, and collected in several places in the St. Lawrence valley, from Rivière du Loup to Montreal. Last winter I endeavoured to call the attention of the members of the Natural History Society to a short consideration of this subject. On looking over this brief sketch (*vide* Canadian Naturalist, vol. 6, page 452) I find two or three errors have crept in, caused by my want of access to the proper authorities on the subject in Quebec. In the present paper I hope to be able to rectify these mistakes. I propose, partly from original enquiry, and partly availing myself of the labours of others, to collect together in one paper, all that we know of the geographical distribution of the inland mollusca of Lower Canada, up to the present date. I shall also indulge in some general speculations which the subject naturally suggests to my own mind.

Let us first consider the most obvious geographical affinities of the land and fresh-water shells of the district in question. Eleven of our Lower Canadian species occur also west of the Rocky Mountains. These are,

Margaritana margaritifera, Linn.
Valvata sincera, Say.
Physa heterostropha, Say.
" hypnorum, Linn.
Planorbis corpulentus, Say.
" trivolvis, Say.
Limnæa stagnalis, Linn.
" palustris, Mull.
" catascopium, Say.
" solida, Lea.
(= L. apicina, Lea.)
" pallida, Adams.

According to Mr. Binney, the Planorbis glabratus of Say also inhabits both the Pacific and Atlantic sides of these mountains, but as yet this species has not been detected in Lower Canada. Again, in this Province we have several species, partly land and partly fresh-water, which also inhabit the continent of Europe. Some of these shells, however, present slight differences, and have been considered distinct species. Thus the following unquestionably inhabit both sides of the Atlantic,

Helix hortensis, Muller.
" rufescens, Pennant.
" pulchella, Muller.
Bulimus lubricus, Mull.
Margaritana margaritifera, Linn.
Physa hypnorum, Linn.
(= P. elongata, Say.)
Limnæa stagnalis, Linn.
(= L. jugularis, Say.)
" palustris, Linn.
(=L. elodes, Say.)

The following European and Canadian species may prove identical:

Lower Canada.		*Europe.*
Limax campestris, Gould.	=	Limax agrestis, Muller.
Vitrina limpida, Gould.	=	Vitrina pellucida, Muller.
Succinea obliqua, Say.	=	Succinea amphibia, Linn.
" ovalis, Say.	=	" Pfeifferi, Rossmäss.
Helix chersina, Say.	=	Helix fulva, Muller.
Physa heterostropha, Say.	=	Physa fontinalis, Linn.
Pisidium Virginicum, Brongn.	=	Pisidium amnicum, Muller.
Anodonta cataracta, Say.	=	Anodonta cygnea, Linn.

It may be observed that a much larger percentage of the *marine* shells of the Gulf of the St. Lawrence also inhabit Great Britain and Northern Europe. Dead shells of the European Helix cellaria have been found by Mr. Fowler near gardens in Craig Street, Montreal. Helix rufescens, probably has also been introduced from Europe, and possibly Helix hortensis. The remainder would appear to be of exclusively North American origin, and confined to the region east of the Rocky Mountains.

Unio Canadensis of Lea is supposed, as yet, to be peculiar to Lower Canada. It is, however, a species but little understood and may be detected in the northern New England states. A Valvata found by Mr Bell at Matanne, and Little Lake Matapedia, and perhaps new to science, I have never found in the New England states. It resembles so closely a depressed variety of Valvata piscinalis of Europe, that I hesitate to separate it from that species. The whole of the land and fresh-water shells of Lower Canada, with these two exceptions, are also found in New England.

But in endeavouring to generalize on the geographical distribution of the mollusca in Canada, we cannot afford to ignore the additional evidence afforded by our knowledge respecting other groups of animals, and of the sister science of botany. It will be more philosophical to consider the geographical distribution of plants and animals *generally*, than to take any one isolated group of animals for *special* consideration and study.

Mr. Woodward, in his excellent " Manual of the Mollusca," has considered that the peculiarities of the molluscan fauna of Canada, are so well marked that we are justified in considering the Canadian as a distinct Natural-history province. This view I have endeavoured to show, in a previous paper, is not borne out by an increased knowledge of facts. The naturalist, looking on the map of Canada, observes an irregular peninsula stretching down to the southwest, and at its furthest extremity running parallel to the state of Ohio. From that state it is divided by Lake Erie, which at this point varies from thirty to sixty miles in width. Cutting off this peninsula (say from Georgian Bay in Lake Huron on the west, to Toronto on the east,) we have then left the greater part of Upper and the whole of Lower Canada. The animals and plants of this peninsula appear to have decided affinities with the western Natural-history province. Thus, in the museum of the Natural History Society, the few fresh-water shells from this region are well known western forms. As examples I may cite:

Unio fragilis, Raf.
  (= U. gracilis, Barnes.)
" subrotundus, Raf.
  (= U. circulus, Lea.)
" costatus, Raf.
  (= U. undulatus, Barnes.)
Unio flavus, Raf.
  (= U. rubiginosus, Lea.)
" quadrulus, Raf.
  (= U. lacrymosus, Lea.)
Physa gyrina, Say.

Judging from what we know of the zoology and botany of the Canadian area, exclusive of this peninsula, its fauna and flora would seem to be of a mixed character. In Dr. Hooker's essay on Arctic Plants, published in the Transactions of the Linnean Society, he includes a large part of Canada in his sub-arctic botanical province. Long before I had seen this paper, I had come to the same conclusion from the little I knew of the zoology and botany of Lower Canada. The marine shells of the Gulf of the St. Lawrence correspond remarkably with the shells of comparatively high northern latitudes in Europe: their boreal character is obvious. As indicating a sub-arctic flora, we may point out with Prof. Schouw, "the total absence of tropical families, and a noticeable decrease of forms peculiar to the temperate zone; the prevalence of forests of firs and birches; the abundance of Saxifrages, Gentians, species of Arenaria, Silene, Dianthus, and Lycopodium, the quantity of mosses, and the number of willows and sedges." Such marine shells again as :—

Pecten Islandicus, Chemn.
Leda caudata, Donovan.
(= L. minuta, Fabr. & Mul.)
Crenella nigra, Gray.
Crenella decussata, Montagne.
(= C. glandula, Totten.)
Serripes Grœnlandicus, Ohemn.
Astarte elliptica, Brown.
" compressa, Linn.
Tellina proxima, Brown.
Tellina Grœnlandica, Beck.
(= T. fusca, Say, T. Balthica, Lov.)

Cemoria Noachina, Linn.
Margarita undulata, Sow.
" helicina, O. Fabr.
Trochus alabastrum, Beck.
(= T. occidentalis, Migh.)
Scalaria Grœnlandica, Chemn.
Natica clausa, Brod. & Sow.
" pusila, Say.
(= N. Grœnlandica, Chemn.)
Admete viridula, Fabr.
Trichotropis borealis, Brod. & Sow.

Tectura testudinalis, Mull.
Lepeta cæca, Mull.

from the Gulf of the St. Lawrence, are not only typical boreal forms, but have been dredged by Messrs. McAndrew and Barrett on the coasts of Norway and Finmark. The proximity of one of the cold currents of the gulf stream, and the extremely low southern limit of floating ice on this side of the Atlantic, might indeed lead us to suspect the sub-arctic nature of the marine invertebrata of the estuary of the St. Lawrence. It appears to me that the boreal or sub-arctic character of the fauna and flora of part of Canada is tolerably well established.

The animals and plants of Canada, geographically speaking, have yet other affinities. What has been termed by Mr.

Woodward, the Atlantic region, includes the New England states, and all of the more southern states east of the Alleghanies. These mountains appear to divide two well marked groups of land and fresh water-shells. Corresponding perhaps with this zoological province, is the region of Asters and Solidagos, of Prof. Schouw. The difficulty is to separate the flora of the region east of the Alleghanies from that to the westward of those mountains. For although the fresh-water shells, of Pennsylvania, for instance, have a distinct general aspect from those of the state of Ohio, yet the plants of the two states are puzzlingly alike. That is to say, if we try to instance any group of plants, (neither mountainous and probably sub-arctic species, on the one hand, or species naturalized from Europe on the other,) we shall find it very difficult to give a list of species that do not inhabit both sides of the Alleghanies. Yet such plants as Magnolia glauca, Spiræa tomentosa, Tillœa simplex, Gnaphalium decurrens, Kalmia latifolia, Azalea viscosa, with several species of Aster, Solidago, Nabalus (?), and Vaccinium, may be considered perhaps as constituting a fair example of the Atlantic flora. Prof. Schouw's region is described as being characterized by the paucity of Cruciferæ, and Umbelliferæ, by an almost total absence of true heaths, which are represented by Vaccinium, and Gaylussacia ; and by the abundance of Asters and Solidagos. This province has not been well defined from a geographical point of view. On the supposition that the Atlantic region, as defined geographically by Mr. Woodward, corresponds with Prof. Schouw's botanical province, I think we may see that in its fauna and flora, part of the Canadian area has affinities with this general natural-history region.

Almost all our Lower Canadian land and fresh-water shells are found in the Atlantic states, north of Cape Hatteras. The same is the case in Upper Canada, so far as we know, with the exception of the southwestern peninsula of that province, as previously defined. It is true, that some small fresh-water bivalves, of the family Cycladidæ, have been described from the neighborhood of Lake Superior, which have not yet been found anywhere else ; but these most likely came from the south shore of the lake, in the state of Michigan, and probably belong to the western natural-history region. In Lower Canada, again, many species of Solidago and Aster abound ; the genus Erica appears to be wholly absent, several species of Vaccinium and a Gaylussacia (G. resinosa) appearing instead, while the paucity of species of the large families of Umbelliferæ and Cruciferæ is quite noticeable in Lower Canada.

The line of demarcation between the Canadian part of Dr. Hooker's sub-arctic region, and the outlier, so to speak, of the Atlantic region, in Canada, cannot be accurately defined. No isothermal line will suffice, for the simple reason that since the creation of the still existing fauna and flora, such physical changes have been effected, that the isothermals during the newer tertiary period must have been constantly varying. To sum up this part of our subject,—we have, as it seems to me, in this vast province, fragments, so to speak, of three natural-history regions. Canada, on the whole, as defined on the map, has not a race of animals, or a group of plants which are so special and peculiar to it as to constitute a good natural-history province. As I have endeavoured to shew, the southwest peninsula of Upper Canada is an outlier of the western region; and the remainder of Canada is partly of a sub-arctic type, and partly, so far as its zoology and botany are concerned, has affinities with the northern Atlantic states. With one remark I shall close this part of our subject. Prof. Asa Gray has shown us that the plants of eastern North America bear a greater resemblance to those of Japan, than those inhabiting the tract of land between the Rocky Mountains and the Pacific. At a meeting of the Natural History Society of Boston, Dr. Gould exhibited a marine bivalve shell (a species of Leda) also from Japan, which he considered identical with a living Massachusetts species. It would be interesting to the naturalist to know if the same similarity obtains between the mollusca, &c., of the two countries, as the relations of their flora would seem to warrant.

But in order to be enabled to speculate with any degree of accuracy on the rationale of the present geographical distribution of animals and plants, we must also carefully glean what little evidence we may from the geologic record. Since the creation of at least some of the animals and plants which still people Europe and North America, mighty physical changes on the earth's surface have been apparently effected, to the consideration of which, as bearing directly on my subject, I would call some attention. Dr. Dawson has carefully catalogued the drift fossils from Beauport, the neighborhood of Montreal, Green's Creek on the Ottawa, and part of Maine. To match these we want complete and accurate lists of the marine invertebrata of the Gulf of the St. Lawrence, and carefully prepared catalogues illustrative of the zoology and botany of the interior of Canada. From Mr. Bell, and from other observers we learn that many of our common fresh-water shells occur in post-pliocene beds of much higher antiquity than our lacustrine marls, while one, if not two, of our Lower Canadian land snails, is of as high an antiquity as the Upper Eocene formation. The Helix labyrinthica of Say, a little snail not uncommon in a living state in Canada, has been found fossil in the Upper Eocene limestones of Headon Hill in the Isle of Wight, and also in the Paris basin. It has been suggested too, that the Helix omphalos, of Searles Wood, another of the Headon Hill fossils, is identical with a living Canadian snail, the Helix striatella of Anthony.

The late lamented Edward Forbes has shown us the importance of studying the fossils of the newer tertiaries in connection with the distribution of living animals and plants. It appears to me to be well, in order clearly to understand our subject, briefly to epitomize, as on a former occasion, his brilliant and most profoundly philosophical generalizations. On the tops of the mountains near the lakes of Killarney, in Ireland, occur a few plants, entirely different from those of the mountains of North Wales and Scotland, but nearly agreeing with those of the Asturian mountains in the north of Spain. According to Forbes, the southern character of these few plants, and their extreme isolation, (together with collateral facts respecting the peculiar distribution of the marine invertebrata of that region) point to a period when a great mountain barrier extended across part of the Atlantic, uniting Ireland with Spain. Soon after this, arguing from similar data, he infers that another barrier of high land connected the west of France with the southwest of England, and thence with Ireland: while a little later England and France were connected by dry land towards the eastern end of the English Channel. As tending to prove this latter view, we may cite the fact, well known to European geologists, that one fresh-water and one land snail, (Bithinia marginata, and Helix incarnata) abundant as post-pliocene fossils in the valley of the Thames, are still living in France, though extinct in Great Britain. At the time of the glacial drift, what are now the summits of the Scotch and Welsh mountains, were then, Forbes argues, low islands, or members of chains of islands, extending to the area of Norway, through a glacial sea, and clothed with an Arctic vegetation, which in the gradual upheaval of those mountains, and consequent change of climate, became limited to the summits of the new formed and still existing mountains. Few botanists who have climbed the Scotch Highlands, will fail to recollect the little isolated patches of Arctic plants on the highest mountain summits, which never occur at a less altitude than from 3000 to 3500 feet above the sea level. Well do I remember standing one fine August morning on the apex of Ben Lawers, the clouds at my feet obscuring everything below, the warm sun shining in the deep blue sky above, and admiring the glorious hue of the Alpine forget-me-not (Myosotis alpestris) the two rare mountain Saxifrages, (S. nivalis and S. cernua,) and a whole array of characteristic ferns, mosses, &c. But I am digressing. After the gradual re-upheavals subsequent to this state of things, it is believed that Ireland was connected with England, and England with Germany, by vast plains, fragments of which still exist as submarine elevations of the land on the west coast of Ireland, charged with the familiar fossils of the period. Upon these lived numerous animals, some of which, as the musk ox, red deer, and horse, yet live. Others, again, as the Arctic elephant (Euelephas primigenius), the two-horned Rhinoceri (Rhinoceros tichorinus, and R. leptorhinus), cave bear (Ursa spelæa), hyæna, etc., though now extinct in Great Britain, have left behind their bones, teeth etc., as post-pliocene fossils in the gravels and clays of our English drifts. According to D'Archiac, the separation of the British Islands from France took place after the deposition of the gravels of the valley of the Somme, in which flint implements have been found. And hence it has been inferred "That the primitive people, to whom we attribute the hatchets and other worked flints of Amiens and Abbeville, might have communicated with the existing country of England by dry land, inasmuch as the separation did not take place until after the deposit of the rolled diluvial pebbles, from among which the hatchets and other objects, have been collected."

The discovery of the fossil remains of an elephant in Sicily, near Syracuse, and at Palermo, identical with the living African species (*vide* Dr. Falconer,) renders it also probable that man lived in Europe at a time when what is now the Mediterranean was a mighty fresh water river. But to come nearer home. It has been held by many of the most eminent geologists that the great depression and subsequent gradual re-upheaval of the land during the post-pliocene age, in Northern Europe and Asia, also took place in temperate north America. Sir Charles Lyell, after careful study of the drift fossils of the United States and Canada, first propounded this theory, which has since been so ably advocated by Dr. Dawson. Throughout all Canada, at any rate east of the Niagara escarpment, we find, often at considerable heights above the level of the sea, stratified deposits of sand and clay, full of marine shells etc, generally of species which still inhabit the Gulf of the St. Lawrence. These have been so carefully and ably described by Dr. Dawson, that I need here do little more than refer to his papers on this subject. It seems pretty clearly proved that, at the time when these deposits were formed, the whole of Lower Canada was submerged beneath the ocean, with only the very highest points of the land left high and dry.

To explain the great cold which is supposed to have obtained over temperate Europe during the post-pliocene period, it has been ably and ingeniously suggested that at the time of the general depression of the land, the isthmus of Darien, or part of it at least, was submerged and the direction of one of the great currents of the gulf stream consequently changed. Thus the warm current which now washes the Western shores of Great Britain, then, it is urged, ran up the west coast of north America; while the cold current now washing the mainland of Labrador, then flowed around the small area of Europe left unmerged. When the re-upheaval of the land took place, the isthmus of Darien would form an impassable barrier against ocean currents, and would tend to produce the present state of things. Of later years we have obtained a few more facts bearing directly on this theory. Mr. Woodward, quoting the views of Prof. C. B. Adams, states in his Manual, in 1856, that only one marine shell (Purpura patula) is common to both sides of the isthmus. But on referring to Mr. Carpenter's able report on the mollusca of the west coast of North America, (Reports of the British Association for the Advancement of Sience, 1857,) we find very different views entertained. Thus he gives a list of thirty-five species which *unquestionably* live both on the Atlantic and Pacific shores• To these he adds twenty-four species which are *probably* common to both sides, and forty-one species inhabiting the same area, which he considers "really separated but by slight differences." It is to be remarked that our knowledge on these points is so limited, that when large series have been procured, many species now separated, may be considered identical. And from later sources, we learn that some species, not included in this Report yet inhabit both oceans. (A series of marine shells collected at Mazatlan by Mr. Moores of Columbus, Ohio, was exhibited to support this view.) Further to the north it is noticeable that several shells, mostly littoral species, occur on both the Pacific and Atlantic shores. Modiola modiolus, Crenella discrepans, Trichotropis borealis, and Bela turricula, inhabit Oregon, north-eastern America, and northern Europe. Referring again to Mr. Carpenter's Report we see that sixteen species of Arctic mollusca inhabit both the Atlantic and Pacific. These are :—

Rhynchonella psittacea, Gmel.
Mya arenaria, Linn.
Machœra costata, Say.
Tellina solidula. (T. fusca, Say.)
Mactra ovalis, Gould.
Mytilus edulis, Linn.
Anomia patellifornis, Linn.
Margarita arctica, Leach.
" helicina, Mole.
Trichotropis borealis, Brod. & Sow.
Admete viridula, Fabr.
Scalaria Grœnlandica, Chemn.
Natica clausa, Brod. & Sow.
Purpura lapillus, Linn.
Fusus Islandicus, Linn.
" antiquus, Linn.
Trophon clathratus, Linn.

The majority of these are species of considerable geographical distribution; all but two (Machœra costata and Mactra ovalis) also inhabit northern Europe. The Tellina nasuta of Conrad, from Oregon, may be a geographical variety of the Tellina proxima of the eastern coast. In like manner Turritella Eschrichtii may be Scalaria borealis, and Littorina Sitchana of Philippi (also from Oregon) may be only a variety of Littorina patula. We have seen that eleven of the Lower Canadian fresh-water shells also inhabit the west coast of North America. Yet the grand chain of the Rocky Mountains intervenes, presenting, according to the views of most naturalists, an impassable barrier to migration. How then can we account for this apparent anomaly? Admitting that during the post-pliocene period, a great, but gradual depression of the land took place on this continent, do we not begin to see our way a little more clearly? When the mountain tops alone were left uncovered by the ocean, these snails, for instance, could only remain on, or near, the dry land, and when the land re-assumed its present shape and general physical condition, the whole area would be peopled, in part, from these sources. For supposing these creatures confined by the above mentioned causes to what are now the peaks of the Rocky Mountains, it is not difficult to conceive, that on the gradual re-elevation of the land, these molluscs could extend in both an easterly and westerly direction. Whether the theory I have advanced be true, or whether it is more likely that such sluggish creatures as fresh-water snails should have travelled the entire breadth of this great continent, and have surmounted such obstacles as a mountain chain, the highest peaks of which are from 15,000 to 18,000 feet above the level of the sea, and clothed with perpetual ice and snow, I leave for naturalists to determine.

The large proportion of marine invertebrata common to the coasts of eastern North America and northern Europe has been thought to imply the existence of a pathway across the Atlantic since the creation of the existing flora and fauna. We have seen that eight at least (and probably double that number) of the inland mollusca of Canada also inhabit northern Europe. Some such theory as the one I have alluded to, would seem necessary to explain this rather peculiar geographical distribution. Dr. Hooker's theory of the south westward migration of the Scandinavian flora, and of its subsequent return under altered physical circumstances, would seem to be doubtful on geological grounds, also from the Darwinian reasoning called in to support the latter half of his hypothesis. Dr. Dawson has cited the case of two species of Solidago living on Mount Washington, one of which (S. thyrsoidea,) has a limited range in northeastern America, while the other (S. virgaurea,) has a widely extended distribution, living as far north in Arctic America as from 55° to 65°, occurring also in the Rocky Mountains, in Great Britain, Norway, and many places in temperate Europe. He suggests that the plants which extend over so large an area, may belong to the older Arctic flora, and that the other species, of very local distribution, may belong to a newer flora. (The two species cited are not perhaps the best examples that might have been chosen to support this view, as they have been considered identical by some botanists. I would suggest the two cranberries, Vaccinium oxycoccus, and V. macrocarpon, as unquestionably distinct species, illustrating the same point.) If this theory be correct, it may be that those Lower Canadian shells which have a wide geographical distribution may be members of an older fauna than that which is more especially characteristic of a limited area in northeastern America. Judging from our present knowledge of the older post-pliocene deposits of Canada, it is quite remarkable that the species found in the marine beds are almost universally of very wide distribution.

The science of archæo-geology, or in other words, the connection between geology on the one hand and archæology on the other, may receive benefit from a much more rigorous comparison between tertiary fossils and their living analogues. Archæologists tell us there are three epochs in man's history; the first, and oldest, of stone, the second of bronze, the third of iron. The discovery of flint implements in European drifts, together with the evidences afforded by the Pfahlbauten (pile-works) or lake habitations, in Switzerland, have taught us that man was contemporary with many extinct mammals, that were once thought to date back beyond the historic period.

As yet we have no definite proof that man existed prior to the deposition of the older marine deposits of the post-pliocene period, represented in this country by the Leda clay and the Saxicava sand. In the stone period we have evidence of two races of mankind, which in all probability were separated from each other by a considerable space of time. Of the primitive race who made the so-called flint hatchets, spear heads, etc., which have been collected in such numbers in the valley of the Somme, we know but little positively. Contemporary with them were Euelephas primigenius, Bison priscus, Hippopotamus major, Rhinoceros leptorhinus, and R. tichorinus (?), the cave bear—a species said by Owen to exceed in size the grizzly bear of the Rocky Mountains—and the fossil hyæna. The fresh-water shells associated with these, with one exception, are of species still living in France. The solitary exception is the well known Corbicula fluminalis, which now inhabits the Alexandrian canal.

Whether the implements of this race were made for warlike or for agricultural purposes is not positively known. But respecting the men of the second period in the stone age, the Celts, we have much fuller knowledge. So many of their settlements have been discovered in Switzerland that it would be tedious to particularize all of them. For instance, on the lake of Geneva, twenty-four such colonies have been found; on lake Neufchatel twenty-six, and on lake Bienne eleven. The dwellers in these lake habitations belonged however to the bronze epoch, as well as to the later of the two stone periods. Some of these colonies must have been large, judging from the size of the piles and the numbers of the huts. Thus in one of the settlements on lake Neufchatel, remains of 311 cabins of large size have been found, and allowing four inhabitants to each hut, we should have an aggregate of 1244 individuals. From similar data it has been calculated that in Switzerland alone, sixty-eight villages of the bronze period contained nearly 43,000 persons; and in the older or stone period the settlements discovered would accommodate nearly 32,000.

Their dwellings appear to have been circular or square huts, grouped on wooden platforms elevated a few feet above the level of and the water, supported above it by huge piles. Each cabin had a trap-door opening on to the lake, and the whole settlement communicated with dry land by means of a bridge. The huts of the pileworks were built of wood, lined with mud, and on the exterior, boughs of wood interlacing each other. We have been enabled to trace the way they felled the trees for their piles. They would burn a circle round the bottom of a tree, chop the charred part away with their stone hatchets, then alternately burn and chop until the tree fell. We see in the stumps the mark of the fire, and the rude cuts of their stone axes. The piles of the habitations of the men of the bronze period were much more elaborate, being made with metal axes. The lake dwellings were apparently first made by the men of the later stone period, to defend themselves against formidable wild beasts; afterwards, in the bronze age, they were found to be useful in protecting the inhabitants from the incursions of hostile tribes. It has been suggested that bronze was introduced into Europe by the Phœnicians about the time of the founding of Carthage, somewhere about the year 800 before Christ The animals most formidable to the men of the stone period in Switzerland (according to Mr. Lubbock) were the brown bear, (Ursus arctos); the wolf, (Canis lupus); the marsh boar, (Scrofa palustris); the common wild boar, (Scrofa ferus); the Urus or wild bull, (Bos primigenius); and the European bison, (Bos bison). The abundance of bones of of the elk and red deer in these settlements would seem to shew how densely wooded was the surrounding country at this time. Twenty-eight species of quadrupeds, seventeen kinds of birds, three of reptiles, and ten of fishes have been found, in fragmentary condition in the pile works. At the village of Concise, on lake Neufchatel, as many as 20,000 objects have been discovered The stone implements seem to be principally axes, knives, saws, lance and arrow-heads, corn-crushers, &c. These have been elaborately described by Mr. Lubbock in the number of the Natural History Review for January, 1862,—this article is copied entire in Silliman's American Journal for September, 1862. Their arrow-heads the Celts often made out of the bones of animals which they had slain in the chase. Specimens of their food have even been obtained in the shape of unleavened cakes, and as carbonized apples and pears. It is stated that our "rude fore fathers" were sometimes so reduced by hunger that they condescended to eat foxes. Their pottery seems to have been ornamented in the rudest way with their finger-ends and their nails. The men of the bronze age in Switzerland appear to have lived as late as the early Roman period. Remains indicative of a battle-field have been found in one of the Swiss Pfahlbauten of the bronze period, in the shape of swords, pieces of chariots, and Gauliot coins. In Ireland, lake habitations have been observed, but these are probably of more recent origin, and are mentioned in early Irish history. They were mere artificial islands on lakes; but sometimes the Irish like the Swiss, built their settlements on piles running pier-like into the water. Both of these customs appear to be common to savage nations in the historic period. Thus Venezuela obtained its name, in early times, from its supposed resemblance to Venice. From Herodotus we learn that in Pœonian villages the first platform was made at the public expense, but afterwards, at every marriage (polygamy being allowed) the bridegroom was expected to add a certain number of piles to the common support.

Thus it seems that at any rate during the earlier part of the post-pliocene period, two races of mankind have appeared and disappeared from the face of the earth, and with them have disappeared some of the larger and more powerful mammals of the period. Yet the general aspect of the animal and vegetable kingdoms seems to have changed but little from that time.

Some of the leaders in comparative ethnography have indulged in speculations concerning the geological date of the creation of man, in which they assign to the human race a far higher antiquity than the post-pliocene period. Speaking of the flint-implement-making men, Mr. Lubbock observes: "Whether the drift race of men were really the aboriginal inhabitants of Europe, still remained to be ascertained. M. Rutimeyer hints that our geographical distribution indicates a still greater antiquity for the human race." One of our ablest British naturalists goes much further and thus sums up this question. "There was a lapse of prodigious ages since man had appeared on the earth, and through which the savage habits had continued without change. And, immeasurably far back as is the age of the flint implement-making men, *as far*, or *farther back still* from them must we go to trace the primitive abode of the human species. The great battle to prove the existence of man among the mammoths, like many other first battles, has turned out in the end, a mere affair of outposts; and for the real origin of man we must go immeasurably farther back from that remarkable time, into the great pliocene or miocene age. To this period succeeded another, of which we are as ignorant as of that which preceded it. For as the mammoth, Irish elk and cave bear have disappeared from the face of the earth, so did this early race vanish away, leaving their weapons, their bones and their dwellings as the only traces of their existence. Afterwards, at an enormous interval, came another race, the Celts, in many points resembling their predecessors, living in similar habitations, and unacquainted with the use of metals, but more highly civilized and possessed of more highly finished weapons, and, as the Pfahlbauten of the Swiss lakes shew, cultivating cereals, and to a certain degree, a pastoral people." Pointing in the same direction, are Prof. Muller's theories on the origin of language, and the well known speculations of the Chevalier Bunsen. With the philological argument however the naturalist has nothing to do.

In an enquiry of so much interest and consequence, it behoves us to be very cautions. Those naturalists who have read Dr. Falconer's able papers on tertiary mammals will see that, according to that careful observer, each subdivision of the tertiary period is characterized by a group of mammals special and peculiar to it. And, as a whole, we find that the higher animals have a much more limited range in time than the lower forms of life. It would seem that the higher the organism, the less likely would it be to hold its own under trying physical vicissitudes, and altered conditions of whatever kind. Thus foraminiferæ, identical with living species, occur in mesozoic strata; and, as we have seen, one at least of our Canadian land snails lived through nearly the whole of the great tertiary period. The gravels which furnished the worked flints of Amiens and Abbeville are fresh-water deposits, not older, if as old, as the post-pliocene deposits in Canada, known locally as the Leda clay and the Saxicava sand. It is much to be wished that in the accounts both of the flint-implement-making men of the valley of the Somme, and of the inhabitants of the Swiss Phfahlbauten, we had more careful lists of the larger mammals of the two periods. As to the geological date of man's appearance on the earth, as far as I can see, we have no *positive evidence* which would date man farther back, at any rate, than the older part of the post-pliocene.

Thus I have endeavoured to jot down, in rather a cursory manner, some general thoughts which a very short study of Canadian land and fresh-water shells, etc., has suggested to my own mind. It has appeared to me that in order to speculate rationally on the geographical range of the mollusca in Lower Canada, we must take into consideration all the physical changes which have occurred since these creatures were first created. In other words, we should study the post-pliocene fossils of the district in question, and institute a careful comparison between them and the recent shells of the country. Knowing the difficulty of access to scientific works in Canada, I have made a short summary of Edward Forbes's famous essay, and have shortly epitomized Mr. Lubbock's paper on the Swiss Pfahlbauten, hoping that attention drawn to the subject, may possibly result in the discovery of works of human art in our Canadian tertiary or post-tertiary deposits.

NATURAL HISTORY SOCIETY OF MONTREAL.

First Annual Conversazione.

The society having determined to hold an annual conversazione, as a literary, scientific and social reunion of its friends, a committee, consisting of Mr. Stanley Bagg, Mr. Becket, Mr. Robb, and Mr. Rose, with Mr. Leeming, the recording secretary, was appointed to make arrangements, and the meeting was accordingly held in the Society's Rooms on the evening of Tuesday, February 3rd. The following addresses were delivered on the occasion, after which the company enjoyed themselves in examining the Museum and a large collection of works of art, microscopes, etc., furnished for the occasion by friends of the Society.

Principal Dawson, in opening the proceedings of the evening, said:—I have much pleasure this evening in inaugurating a new feature in the progress of this Society—our Annual Conversazione—an occasion on which the members of this Association, with all its beasts, birds and creeping things, announce themselves "at home," and invite their friends to a scientific and intellectual feast, which we hope will continue to grow in interest in each succeeding year, and will remain as one of the permanent institutions of the society and of the city. The last occasion on which we thus entertained our friends was that of the opening of this building, an event of the utmost importance in the history of the society, and which has more than realized the most sanguine anticipations of those who promoted the removal of the Society's collections, and the erection of our new and commodious apartments. Since that time, our collections have been largely augmented; many new members have been added to our list; and our monthly meetings have been amply supplied with interesting communications, many of them marking important steps of progress in the natural history of Canada. We have now connected with this Society, as members and correspondents, nearly all the working naturalists and geologists of British America; and our proceedings, published in the *Canadian Naturalist*, have extended the reputation of the Society throughout the world, and added an immense mass of valuable facts to the natural history of this country. The seven large volumes of our *Naturalist*, and the numbers constantly appearing, now form an indispensable part of the library of every one who studies the natural history of North America. Our labours have also been appreciated at home. The circulation of the *Naturalist* in Canada, and the fact that it is self-supporting, the large attendance at our monthly meetings and public lectures, and the recognition of the Society by the government of the country, as a recipient of a portion of the sums which Canada, in emulation of the wise liberality of older countries, annually grants for scientific and literary purposes, all testify to this. We all wish, however, that the advantages which we offer were still more largely used. Our philosophy is not of that kind which shuts itself up in pedantic exclusiveness. We regard the study of nature as the common heritage of all, and desire to open up to every one, from the little child upward, its beauties and its uses. Placed as I am at the head of an educational institution in which all branches of learning are represented, it does not become me, on ordinary occasions, to magnify my own special office as a teacher of natural science, or to insist on the reasons which have induced me to prefer in my own case the study of nature to other means of improving my mental powers and rendering myself useful to my fellow men. But here, as an officer of this Society, I may be permitted, without disparagement to other kinds of useful knowledge, to state some special claims of the study of nature. And first I would say on this subject, that the study of nature is eminently fitted to develop all our higher powers. Reasoning on first principles, this is absolutely undeniable, and might be stated still more strongly. Man is the only creature on our globe fitted to comprehend nature, and in his primitive state of innocence it was his only book; and as among lower creatures, every one is specially adapted to its condition of life, so there is a special adaptation of the powers of man, created in the image of his Maker, to that system of things proceeding in all its parts from the same Almighty mind. Practical experience confirms this inference. What more fitted than natural objects to call forth the exercise of the powers of observation, what to develope a more nice power of discrimination, what to train to all the intricacies of contingent reasoning. The man who has disciplined his mind by the thorough study of any department of nature, who has gathered together and scrutinized its minute facts, who has by careful induction learned from them general truths, who has mastered, as far as our limited intellects may, the plans of the Creator in any portion of his works, has thereby aquired a mental training more godlike in its character than any that can be gained from art or human literature, because he has been following in the footsteps, not of man, but of God. Farther, natural science grasps within itself the essence of many other departments of culture. All the higher literature and more especially the literature of the sacred books and of the more ancient nations, is imbued with nature. All true art has its foundation in the higher art of creation. The principles of mathematical and physical science have some of their highest applications in the mineral, the plant and the animal; and geology presses into its service the results of almost every kind of inquiry as to material things. For this reason, while nothing can be more simple than the mere elements of the knowledge of nature, nothing can be more intricate or abstruse than its higher questions; nothing is more suited to convince a man of his own ignorance, or to prevent him from resting in a limited range of acquirement, or from remaining satisfied with the rude attempts of man to imitate the perfect beauty and adaptation of natural things. Again, the modes of investigation in natural history bear a direct relation to those modes of thought which are most necessary in the ordinary work of life. Observation, comparison, reasoning from cause to effect,—and these in relation to the means by which the Author of nature carries on his vast operations,—are the leading pursuits of the naturalist; and their effect in producing an acute, yet comprehensive style of thought, is conspicuous in the lives and works of all eminent students of nature. Nor is there anything in natural history calculated to engender pedantry or conceit. The naturalist works in the presence of mysteries of life and structure which he cannot fathom, and which, therefore, teach him humility. He is only the interpreter of that which he cannot imitate; and he is willing, in collecting his facts, to sit at the feet of any one who can inform him in respect to the thousands of ordinary phenomena open to the investigation of every person who observes. Lastly, the revelation of God in nature, like that in his word, is thrown around us in such a way that while a little child may learn much of it, the powers of the highest intellect are tasked in reaching its higher truths, and in correcting the errors in which carelessness and ignorance envelop it. These two great revelations are twin products of the Divine mind: the one the study of man in innocence; the other the safety of man fallen:—and it is true that he who loves God most, will appreciate nature most; he who knows nature best, must best understand its Author. To disparage the study of nature as inferior to any other means of culture, is to evince the littleness of a mind dwarfed by the study of man's doings and blind to those of God, or the impiety of a soul that has no wish to magnify the works which men behold, as the external manifestation of the spiritual Creator.

But I must not follow such thoughts further, and now close by earnestly inviting all who are present this evening, to unite with us in exploring the wonders that are spread everywhere around us in nature, and assuring them that in this matter a little knowledge is not a dangerous, but on the contrary, a pleasant and profitable thing; and that while in Canada, there is scope for many more workers than we now have, there is still more ample scope for all who may desire to understand and enjoy the results of their labors.

Rev. A. F. KEMP next addressed the audience. He said it afforded him great pleasure to be there. Yet he had come there unexpectedly to himself, after rather severe labours during the preceding week; but being a great lover of natural science, he could not shrink from the invitation, and from saying such words as he might be enabled to offer on a subject so deeply interesting to him. Natural science was a most interesting part of human learning: most people liked it: it had a greater charm than most other departments. Amongst children there was a great taste for natural objects. They liked to touch things, and were curious in their inquiries about them. Curiosity was the faculty which in natural science was brought to bear upon nature. Some people, as they grew old, seemed to lose this; and their inquiry as to anything new, was merely as to its utility, and whether it would pay. But those who retain the freshness and vigour of their youth have higher conceptions of the wonderful things with which they are surrounded. I have a great admiration too for what I may call the scientific method of thinking and reasoning. This method could not be satisfied without seeing, knowing, and thoroughly understanding, if possible, all about the objects of nature that lay within the compass of human apprehension. It was close and searching. It can be satisfied only with facts carefully observed and defined as the basis of its conclusions. If anything were omitted in the inquiry, the conclusions would be all wrong: the induction would fall to the ground, like a house of cards. But when it had got all the facts and their relations to one another it could then by the inductive process reach conclusions which might be regarded as reliable and certain. There was an infinite variety in the departments of natural science. Every taste could thus be gratified. Some loved entomology; but, for himself, he did not like to stick pins into butterflies and other insects. The study of animal life was certainly full of interest, but to him there always appeared to be something rather painful, if not cruel, about it. He preferred that department of natural science which had to do with what they might term, insentient life, or that of the vegetable. It was very easy to undertake, and exceedingly delightful. To its student the mighty forests were open, whose trees lifted their heads to heaven, and if he choose he could turn to the more lowly flowers of the field. Wooing them upon the river's banks, he would be repaid with unalloyed healthy pleasure. I profess to have turned my attention a little in this direction. Dr. Dawson had said, the study of natural science made men humble. Then he (Mr. Kemp) must be so, for his part was to study the humblest forms of nature, namely, marine and freshwater plants, many of which could only be observed by means of the microscope; and he would say, that he had felt true exhilaration of mind, and pure pleasure, when he had been in the field engaged in such pursuits. In that employment, he had roamed amongst the cliffs of Bermuda, and been charmed with the sight of that climate's most brilliant marine flora. "I have sometimes had amusing adventures there. One day I remember, when looking round in the hope of discovering some new species, I saw as I conceived one of the more brilliant red plants gleaming bright, at a considerable depth in the water; it moved gracefully with every motion of the waves. I feasted my eyes on its beauty, and thought if only I could secure it without injury how glad I would be. To dive so deep and bring it up was not possible for me, so I got a long branch of a neighbouring tree, and up to the knees in water, on a rock near by, I worked till at last I caught it, and with joy pulled up my prize. But what do you think it was? Why, nothing but a bit of a soldier's red coat! (Laughter.) I was very much disgusted you may be sure. But yet it was so amusing that I enjoyed "the sell" amazingly.

"I do not need to go far for the objects of my study. They are everywhere—on the damp soil, the water spout, the pool, the high-way,—in the streamlet, the river, and the ocean. Pools of stagnant water, covered with a green mantle, were no contemptible fields for investigation. They were not unhealthful, and they were filled with objects, than which few were of greater interest. When upon a large scale, they emitted carbonic acid gas, or miasma the little things which covered them fed upon that gas, and absorbed it, leaving globules of pure and healthy oxygen. Some of these plants were exceedingly complicated and curious, and, to his mind, the most beautiful in the vegetable kingdom. Mr. Kemp here exhibited drawings of *Spyrogyræ* and *Rivulariæ*, and explained the structure and growth of these minute plants, which were constantly to be found growing in stagnant pools or on the banks of streams, and were objects of great interest to naturalists. They were exceedingly prolific, and he considered their peculiar manner of propagation as a proof of the permanency of species, in opposition to the Darwinian theory. Little and lowly they were, yet on examining their structure, and studying their economy, we were led into regions of life most wonderful and mysterious exhibiting the wisdom, goodness, and power of the Creator. Whence life came we could not tell; what it was the microscope could not discover. God concealed himself amidst his works, even while he revealed his power and skill in the outward aspects which they presented. In observing even these minute forms of life one could not but feel the truth of the saying: "Canst thou by searching find out God, canst thou find out the Almighty unto perfection?" For the speaker's part, though his special study was, from choice and profession the Bible, yet he felt bound, at the same time, to unfold and read the wondrous pages of creation. He did not believe it possible for a man to be an infidel, whilst he paid scientific attention to nature. He was glad to see his audience there. The society had left its former humble rooms; and with the occupation of better ones, seemed to have improved in spirit. Let those who were not already members, become so, and begin and prosecute the study of the works of their beneficent Creator.

The CHAIRMAN then rose and thanked Mr. Kemp for his excellent address, saying, that the poet had said, there were "tongues in trees; books in the running brooks, and sermons in stones," but Mr. Kemp had found sermons in stagnant pools.

Selections of music, from Verdi and Donizetti, were then performed by the Band. When these were over, the Chairman introduced the Rev. Dr. De Sola, who said :—

I believe that no member of the Natural History Society will regret that it was decided to hold this pleasant social meeting here, when he looks around and sees how readily and numerously the friends of the Society have come forward this evening, to show their interest in us. And I am sanguine enough to believe that all who have come to-night are friends of the Society, and wish us God-speed in our efforts to promote its objects. And I am also sanguine enough to believe as a consequence, that those days in which the Natural History Society only vegetated, and in which even this vegetative existence was scarcely known to the public, are past, for ever past, without recall. At the same time, I do not forget that though the claims of natural science are becoming better understood, still much misconception as to its ends still exists, and some branches which this institution favors, are even now regarded with suspicion, if not with positive dislike, by many worthy persons who unaccountably fancy that the cause of revealed truth may be injured by them. This is no occasion fully to examine such an objection. We can only say to such timid persons, "Become members of this Society, and judge for yourselves, what powerful support science has given revelation." With reference to this misconception, I may go further and say that had carpers at holy writ been better naturalists, and possessed greater knowledge of physical science, they had not advanced half the fallacies they have. Thus, if the writer of a recent most crude and unfortunate publication, entitled "A critical examination of the Pentateuch and Book of Joshua,"—called critical, perhaps, because there is no evidence of fair criticism in it, on the same principle that a worthy son of Erin called himself rich, because his money could not be counted,—if this writer, I say, had only been a working member of the Natural History Society of Montreal, I am sure that at least some of his objections would not have been started, but he would have recoiled at their absurdity. As an examplè, when he puzzles himself with one of his favorite arithmetical propositions,—"If 600,000 men in London require so much fuel, how much did 600,000 Israelites require in the desert, where trees are few," a member might remind him that the *genus homo* amidst the fogs, damp and cold of London, requires a little more caloric than the *genus homo* travelling under the burning sun of Arabia—that to cook the bread and beef of old England requires a little more fuel than did the manna, the food of the Israelites, which was melted by the mere heat of the sun. We could also whisper to him a few secrets about animal fuel, such as the Arab even now prepares in the desert, and the prophet Ezekiel refers to. We might say something too of the changes taking place on the face of the physical world,—of Lebanon, now barren and once covered with trees—of the present sterility of parts of Palestine, formerly most productive and prosperous, and show that even the wood-fuel they had was not absolutely required; nay, we might give him a rule-of-three sum in return, and say, if 600,000 persons required so much fuel in Arabia, and so much in London, how is it that the same number of persons in these northern regions of Canada, can find cord-wood enough for their supply, when so vast a proportion of these are needy persons, and have not wherewith to supply their wants from day to day? We will volunteer the reply also. The reply is one which all the researches of this Society into the Eternal's works of the natural order, as well as the holy book gives us, and it is that the hand of God never waxeth short, but every thing, and every one, bears incontrovertible testimony to the infinite power, wisdom and benevolence of the Creator of nature. I trust my reference may be excused. But I desired to employ this opportunity to state my humble opinion that if biblical students and religionists will not avail themselves of the advantages conferred by the study of natural science, there is a certain personage who well knows how to use them, as he has ever used them, for the attainment of his own ends. And I desired to illustrate the needlessness of the alarm of some timid ones, and to demonstrate the truth that science is the true friend and supporter of religion, and that therefore, this and kindred institutions should enjoy the unbounded confidence of the community.

In inviting an accession of numbers to our ranks, we think that this Society, as pioneer in the development of natural history in this country, as originator of the present Geological Survey of Canada—for this Natural History Society was certainly first to move here—we believe it has some claims on every Canadian. A certain amount of progress has followed on its efforts, an accession of scientific talent has been made; and when I mention the name of a Dawson, a Logan, a Hunt, and a Billings, I think you will conclude with me that we number among us those of whom any Society even in Europe might be proud. We know that in a young community like ours, where nearly all are engaged in those pursuits which leave little time for scientific researches, we need not hope for a very large number able to take an active part in the primary objects of this Society. But this will not always be the state of things, and we should therefore do something for posterity. We can at least lay up materials for instruction, ready for use when they shall be wanted; and if we only do this, we shall be doing an important work, for which coming generations will thank us. But we are in fact doing more than this. The efforts of the members as they are becoming progressively greater, are also becoming better appreciated. The Society is becoming so favorably known that we may hope to see it yet bearing the same relation to all the British American Provinces as the British Museum bears to the mother country. We therefore ask all who can, to come and aid us in realizing our aspirations, which are chiefly those of the original founders of the Society—that of extending the knowledge of Natural History in particular, and of the physical sciences in general around us, so that our labors may redound to the credit not only of this growing city, but of this colony; and above all, that these labors may be additional testimony to the truth that " the hand that made us is Divine," even the hand of Him whose power, wisdom and benevolence are clearly revealed to us in all that is around.

ORDINARY MEETING, Oct. 24, 1862.

After routine business the following communications were then read and discussed:—

1. A letter from Prof. Hall on the limits of the Catskill Group of New York, showing that a large proportion of the area, more especially in Delaware county, hitherto supposed to be occupied by the Catskill Group, really consists of rocks of the Portage and Chemung Groups.

2. A letter from Dr. Van Courtlandt, on the occurrence of *Gasterosteous gymnetes*, and of a supposed New *Leuciscus* in a lake tributary to the Ottawa.

3. A paper by C. Robb, Esq., C.E., on the distribution of the Superficial Deposits in C.W., and on some phenomena connected with the Mineral Springs of that region; more especially on the fresh-water drift of Upper Canada, and on the local subsidences and peculiar deposits on organic matters produced by some of the Springs.

4. Rev. A. F. Kemp made some remarks on the proposed use of the *Zostera marina* as a substitute for cotton, and on the occurrence of this plant in Eastern America.

Several papers we announced for next and subsequent meetings; and recommendations of the Council in relation to the better, arrangement and labelling of certain departments of the collection, were reported by the Secretary, Mr. Leeming, and adopted.

A number of new members were proposed, and the meeting adjourned.

ORDINARY MEETING, Nov, 24, 1862.

Principal Dawson, vice-President in the chair.

L. H. Parkes, Esq., of Birmingham, England, Microscopist, was unanimously elected a corresponding member; and Col. Dunlop, R.A., Messrs. J. E. Pell, J. S. Millar, Alex. Cowan, and H. G. Vennor were elected ordinary members.

After the general business, the following papers were read;

1. On the habits of the pine-boring Beetles of the genus *Monohammus*; by E. Billings, Esq.. F.G.S.—After some general remarks on the commercial value of our timber trees, and on the numerous insects which attack them, the author noticed the species of *Monohammus* known in North America, and gave a particular account of the habits of *M. Confusor*, with especial refe-

rence to its ravages on the timber of the white and yellow pine; and mentioned some very remarkable illustrations of the number of the insects, and the rapidity with which timber is destroyed by them.

2. On a New Crustacean from the Potsdam Sandstone; in a letter from Prof. Hall to Dr. Dawson—Prof. Hall referred to the paper on the footprints of Limulus recently read before the Society, and stated his belief that a new crustacean recently described by him before the Albany institute, but not yet published, answered to the conditions implied in the formation of Protichnites as illustrated by the modern Limulus.

3. On the Acton Copper Mines; by T. McFarlane, Esq.—In the absence of the author this paper was read by Mr. Robb. It contained an elaborate account of the mine and of the bed containing the ore, with its various disturbances; and entered into the probable origin of the deposit, and the modes of extracting and dressing the ores; being altogether the most complete and detailed account of this remarkable deposit which has yet appeared. The thanks of the Society were voted to Mr. McFariane.

The following donations were presented to the Society:—

From P. McFarlane, Esq.—Specimens of minerals from the Giants' Causeway.

From James Ferrier, Junr. Esq.—A pair of *Fuligula albida;* and fishes for the aquarium.

From Mr. Gavin.—Two specimens of *Coluber sirtalis* (alive).

From Mr. Miller.—Specimens of Copper Ore from the Bruce Mine.

The Dublin Nat. Hist. Review, 6 Nos,; Proceedings of the Dublin University Zoological Association, 2 Nos; Journal of the Franklin Institute; Proceedings of the Entomological Society of Philadelphia, 6 Nos.; and several other periodicals and pamphlets were presented by the editors and publishers.

ORDINARY MEETING, Feb. 2, 1863.

Principal Dawson, the vice-President in the Chair. The following papers were read:

1. On the Land and Fresh-water Mollusca of Lower Canada, with thoughts on their connections with the Post-pliocene fossils of the St. Lawrence Valley, and on the general geograpical distribution of Animals and Plants in Canada; by J. F. Whiteaves Esq. F.G.S.

2. On the parellelism of the Quebec group with the Lower Llandeilo of England and Australia; and on some new or little known species of Palœozoic Fossils. By E. Billings, Esq. F.G.S.

3. On the gold deposits of Canada and the manner of working them. By Dr. T. Sterry Hunt, F.R.S.

The following donations were received:

From L. Thomson, Esq.—Specimen of the Trumpeter Swan.

From G. Barnston, Esq.—Specimens of Fishes and Reptiles.

From Mr. E. C. David—Specimen of Wild Rice from the Prairies.

From B. Gibb, Esq.—Horn of African Rhinoceros.

From Mr. J. O'Brien—Specimen of the great horned Owl.

From Mr. Hunter—Thirty-two specimens of the sternum or breast-bone of Canadian birds.

From S. Bagg, Esq.—Bye-laws of the Numismatic Society of Montreal, and a paper read before the Society.

From T. Roy, Esq.—Pictorial description of the *Victoria regina.*

From J. Ferrier jun., Esq.—Japanese work on fishes, with coloured drawings.

From Various Societies, &c.—Proceedings and publications.

BOTANICAL SOCIETY OF CANADA.

The first meeting of the third session was held in the University Hall, Kingston, on Monday evening, 26th January, Prof. J. R. Dickson, M.D., Vice-President, in the chair.

The Society then proceeded to the election of office-bearers for the ensuing year, when the following were elected:—

PATRON—His Excellency Viscount Monck, Governor General.

PRESIDENT—Very Rev. Principal Leitch, D.D.

VICE-PRESIDENTS—Prof. Litchfield, M.D.; Thos. Briggs, Jr., Esq.; Prof. Dickson, M.D.; Rev. Prof. Williamson, LL.D.

COUNCIL—John Carruthers, Esq.; Rev. W. Bleasdell, A.M., Rector of Trenton; Professor Kennedy, M.D.; B. Billings, Jr., Esq., Prescott; Prof. Fowler, M.D.; M. Flanagan, Esq., City Clerk; Mr. J. Macoun, Belleville; Prof. Hincks, F.L.S., Toronto; Prof. H. Yates, M.D.; Hon. W. Sheppard, D.C.L., Drummondville, L.C.; W. Ferguson, Esq.; J. Duff, Esq.; M. Sullivan, M.D.; Rev. H. Mulkins; Professor Octavius Yates, M.D.; Prof. Lavell, M.D.; Judge Logie, Hamilton; Augustus Thibodo, Esq.; Rev.

Prof. Weir, A.M.; John Watkins, Esq.; J. Creighton, Esq., Mayor; Rev. Prof. Mowat, M.A.

SECRETARY—Professor Lawson, LL.D.
AUDITOR—Andrew Drummond, Esq.
TREASURER—Professor Murray.
LIBRARIAN—Mr. R. V. Rogers, B.A.

HERBARIUM COMMITTEE—Mr. A. T. Drummond, B.A.; Mr. W. B. Ferguson, Jr., B.A.; Mr. John Bell, B.A.; Mr. Robt. Jardine, B.A.; Mr. John McMorine; Mr. James B. Ferguson, B.A.; Mr. Josiah Jones Bell.

Professor Lawson stated that through the kindness of Professor Caruel, formerly of Florence, now at Pisa, an ample supply had been obtained of living cocoons of the new Chinese silk moth, *Saturnia Cynthia*, which yields the Ailanthine silk, now so successfully raised in France and Italy. The eggs, which may be obtained from the moths in May next, it is proposed to distribute to such members of the Botanical Society as may desire to aid in the experiment of rearing them in Canada. This silk worm feeds on the *Ailanthus glandulosa*, a tree that is quite hardy in Canada. Members desirous of obtaining eggs were invited to send in their names to Professor Lawson, who stated that although there had hitherto been experienced great trouble in unwinding the cocoons, the process of soaking in caustic potash which Mrs. Lawson had found to answer so well with the Canadian Cecropia cocoons, was no doubt equally applicable to the new Ailanthine silk. Professor Lawson likewise exhibited samples of cloth made in the Indian prisons from the floss of the Indian silk weed or mudar plant, a material precisely similar to the floss contained in the pods of Canadian silkweeds.

Mr. Rogers, the Librarian, presented the following donations to the Society's Library :—

1. From the Montreal Natural History Society—The Canadian Naturalist and Geologist, from February 1862, to January, 1863.

2. From the American Philosophical Society—Nos. 66 and 67 of their proceedings.

3. From the Boston Society of Natural History—Their proceedings, Vol. 8, pages 1 to 128.

4. Proceeding of the American Academy of Arts and Sciences, Boston, Vols. 1, 2, 3, 4, and 5,—from the Academy.

5. Annals of the Lyceum and Natural History of New York, Vol. 8. Nos. 10 and 12,—from the Society.

6. Treasures of the Deep or Scottish Sea-weeds,—from Mr. Hubbert, Knox's College, Toronto.

7. Observations on North American and other Lichens, by Ed. Tuckerman,—from the author.

8. Physical features of central part of British North America, by James Hector, M. D.,—from the author.

9. Alpine and Arctic plants. by Principal Dawson,—from the author.

10. John E. LeConte, a necrology, by Wm. Sharswood,—from the author.

11. From Robert J. Drummond,—Botanical sketches of the 24 orders of Linnæus; Sir J. Banks and the Royal Society; Linnæus and Jussieu, or the Rise and Progress of Systematic Botany; annual Report of the Natural History Society of Montreal, for 1862; Constitution and By-Laws of Natural History Society of Montreal.

12. From the Geological Survey—Descriptive Catalogue of Economic Minerals, &c., of Canada, sent to the London International Exhibition, 1862.

Donations of dried specimens were announced from Mr. John Bell, B. A., Mr. Josiah J. Bell, Mr. C. I. Cameron, Mr. John Macoun, Mr. John K. McMorine, Mr. Donald Ross, M. A.

The following communications were read:

1. On plants collected in Canada, by Philip W. Maclagan, M. D; Berwick upon Tweed.

Referring to the recent establishment of the Botanical Society, Dr. Maclagan observed :—Entertaining, as I always must do, a warm affection for Canada, and my many kind friends there, I was delighted to see that Botany was taking its right place among them. I wish that there had been any movement in this direction during my residence, for I often had to regret the want of some companion to share the pleasure of botanical researches. Pondering in what way I could best show my sense of the compliment paid to me by your Society, I resolved to send you a complete list of the plants I had myself collected, and of which I have specimens, during a residence in Canada extending over twelve years, in the course of which I had been stationed in various parts of the country.

Dr. Maclagan's detailed observations, which were contained in two M.S. volumes, and embraced original information respecting nearly 900 species of Canadian plants will be published in the

Society's annals. A cordial vote of thanks was accorded to the author.

2. On the Physical Character of the East Riding of Northumberland, with a list of the plants of Mr. John Macoun, Belleville. Read by the Rev. Prof. Mowat, M. A.

This was likewise a very valuable paper and will appear in the Annals. Mr. Macoun's list embraced about 800 species. The account of the physical character of the country, and the indications of its former condition, shown by ancient lake-terraces, &c., excited much interest, and the Society's thanks were voted to Mr. Macoun.

3. Account of an Exploration of Gaspé during the past summer, by John Bell, B.A.

Mr. Bell, as one of a party of the Geological Survey, spent the summer in exploring the wild spruce woods of Gaspé, and gave a very interesting account of the vegetation. Mr. Bell has added greatly to our knowledge of Gaspé plants, and obtained some species that had not previously been observed. The Society accorded him warm thanks. Mr. Bell is preparing a complete list of his collections, which were very extensive, and the list will be printed in the Society's Annals.

4. On Ailanthine, the silk yielded by the *Saturnia*, or *Bombyx Cynthia*, with remarks on the *Ailanthus glandulosa*, or false Varnish Tree, of China, upon which the Worm feeds, by Robt. Patterson, M.D., Read by the Rev. Prof. Murray.

In illustration of this elaborate and valuable paper which will be published, the author sent a very interesting series of specimens, which were exhibited to the meeting, showing the eggs, the larvæ in various stages, the cocoon, and the perfect moths, male and female. The Society's best thanks were voted to Dr. Paterson for his communication.

5. List of plants collected in Ramsay and adjoining localities, during 1861-62, by John K. McMorine.

6. List of plants collected chiefly at Fort Garry, Red River Settlement, by John C. Schultze, M.D.

7. List of Plants of Beckwith and Ramsay, C.W., by Josiah Jones Bell.

8. List of Plants collected at Wellington, during the summer of 1862, by John A. Kemp, M.D.

The above lists were laid on the table and authorized to be printed. The reading of several papers was delayed till next meeting, to be held on the evening of Friday, 13th of February.

The second meeting of the third session, was held on Friday evening, 13th Feby., the Very Rev. Principal Leitch, D.D., President, in the chair. There was a full attendance of members.

Professor Lawson, the secretary, called attention to the proposal of the Home Government, to publish under the direction of Sir William Hooker, the Queen's Botanist, Floras of the colonies of the British Empire, and a communication was read from Judge Logie of Hamilton, on the subject. Application having been made by the Colonial Secretary for the approval and concurrence of the Canadian Government, with a view to the early publication of the Canadian Flora, several of the members expressed strongly their opinion of the importance of the scheme, both in a scientific and commercial point of view, and as affording a most effectual means of making known to Canadians, as well as to the inhabitants of European countries, the nature of the products of our rich Canadian forests, which would stimulate to new branches of industry, and to the development of commercial enterprise.

Dr. Dickson, V. P., moved the appointment of a committee to bring before the Legislature, by petition and otherwise, the importance of Sir William Hooker's proposed publication, and expressed a belief that, if the Government declined to grant the small sum required, persons would be found in Canada ready to raise the amount, in a very short time, by private subscription. Committee: Principal Leitch, Prof. Dickson, Rev. Mr. Mulkins, A. Drummond, Esq., Judge Logie, and Professor Lawson.

The following papers were read:—

1. On the *Selandria Æthiops* and its destructive effects on Pear Trees. By the Very Rev. Principal Leitch, D.D., President.

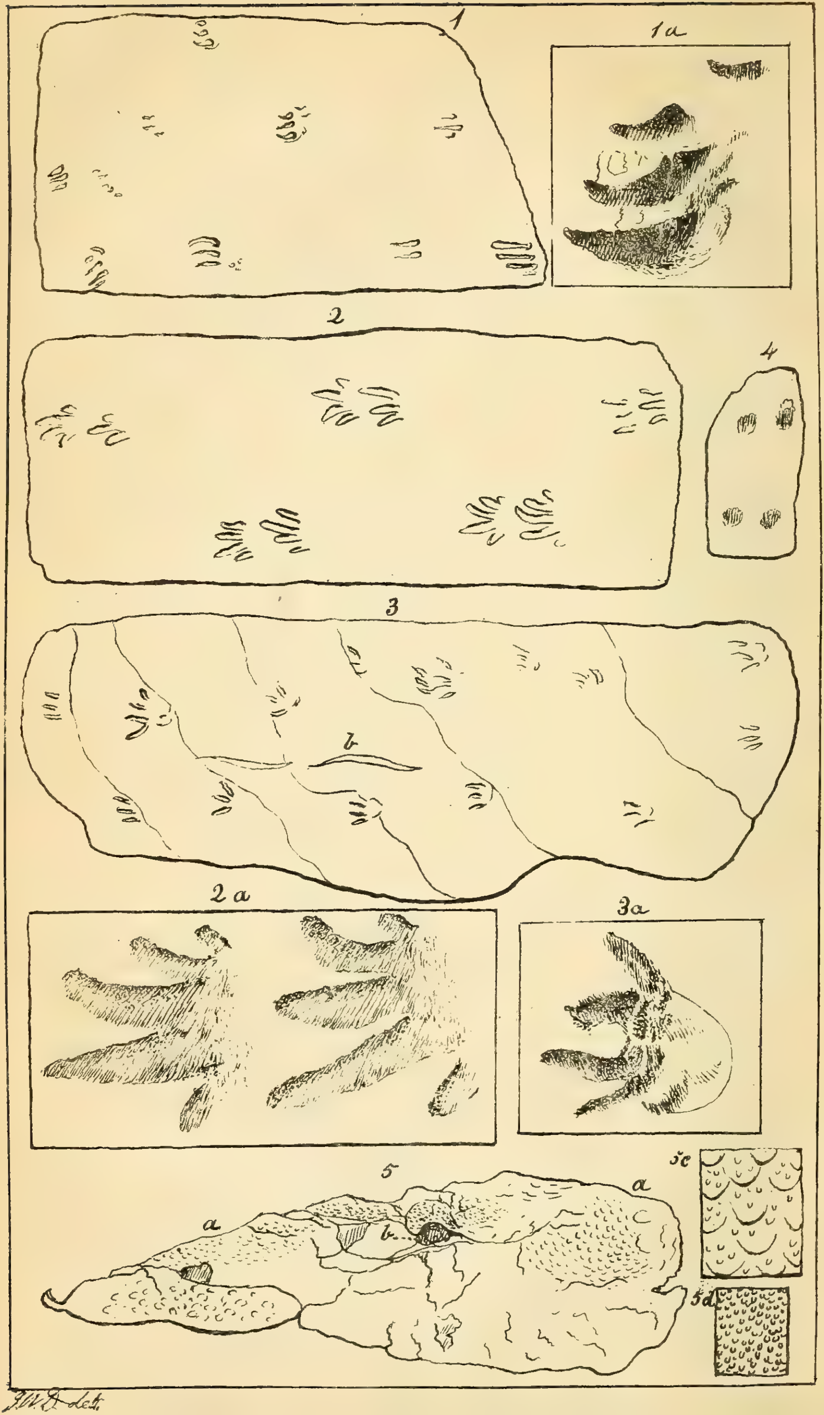
2. Additional remarks on Dr. Patterson's paper on Ailanthine, by the Very Rev. Principal Leitch, who gave a very interesting detail of the rearing of the Ailanthine Silk Worm in Dr. Paterson's garden at Leith.

3. Poem.—The Pines. By Charles Mair, Lanark, C. W. Read by Joshua Fraser, B. A.

4. A chapter on Fungi. By James Hubbert, Knox's College, Toronto.

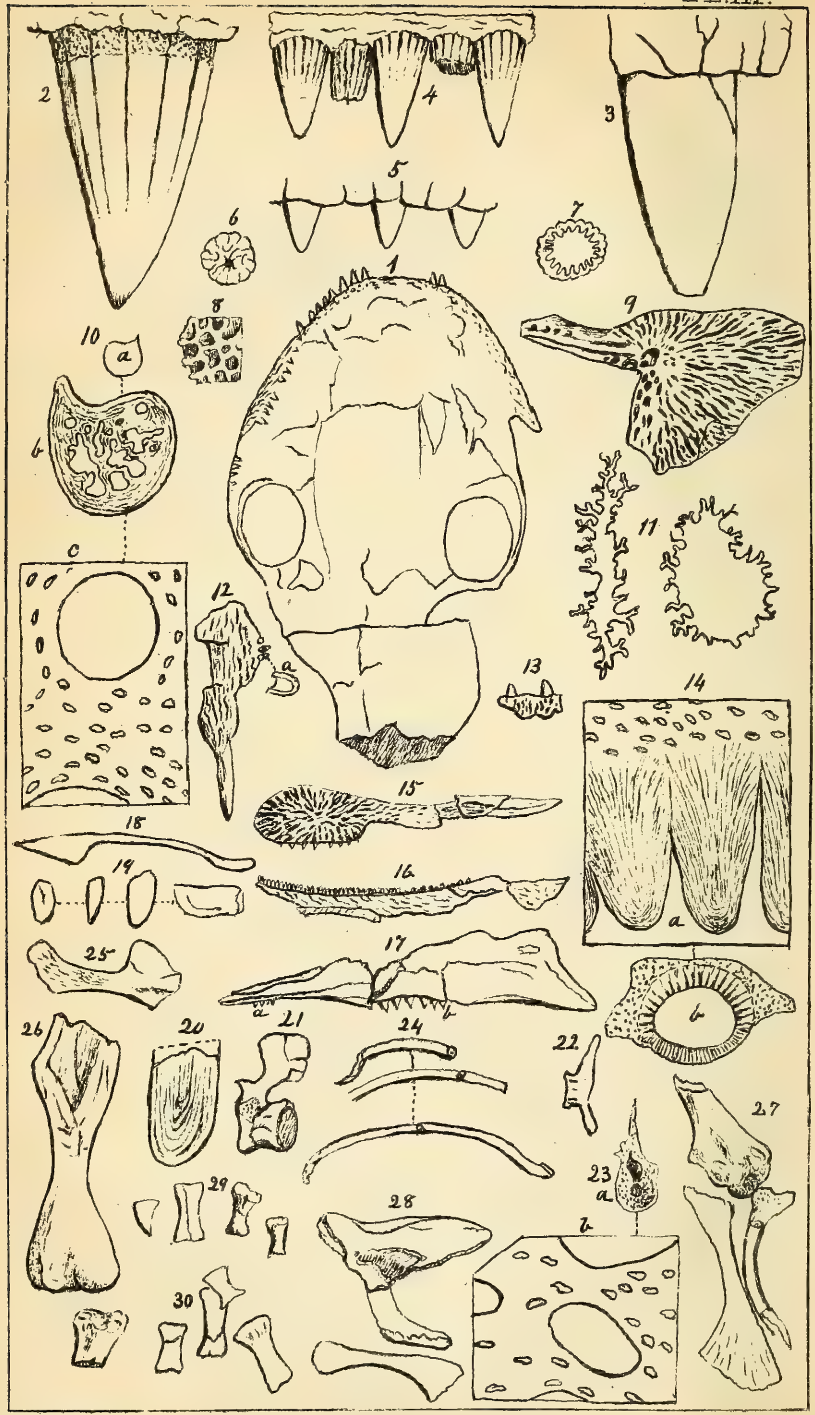
The Society then adjourned until Friday, March 13.

PL. 1.



J.W.D. del.

FOOTPRINTS &c.



W. D. del.

DENDRERPETON ACADIANUM. *Owen.*

THE

CANADIAN

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ART. VI.—*The Air-Breathers of the Coal Period in Nova Scotia;* by J. W. DAWSON, LL.D., F.R.S., &c.

(*Continued from page* 12.)

IV.—DENDRERPETON ACADIANUM.

Plate III.

The geology of Nova Scotia is largely indebted to Sir Charles Lyell. Though much had previously been done by others, his personal explorations in 1842, and his paper on the gypsiferous formation, published in the following year, first gave form and shape to some of the more difficult features of the geology of the country, and brought it into relation with that of other parts of the world. In geological investigation, as in many other things, patient plodding may accumulate large stores of fact, but the magic wand of genius is required to bring out the true value and significance of these stores of knowledge. It is scarcely too much to say that the explorations of a few weeks, and subsequent study of the subject by Sir Charles, with the impulse and guidance given to the labors of others, did as much for Nova Scotia, as might have been effected by years of laborious work under less competent heads.

Sir Charles naturally continued to take an interest in the geology of Nova Scotia, and to entertain a desire to explore more fully some of those magnificent coast sections which he had but hastily examined; and when, in 1851, he had occasion to revisit the United States, he made an appointment with the writer of these pages to spend a few days in renewed explorations of the cliffs of the South Joggins. The object specially in view was the thorough examination of the beds of the true coal measures, with reference to their contained fossils, and the conditions of accumulation of the coal; and the results were given to the world in a joint paper on "The remains of a reptile and a land-shell discovered in the interior of an erect tree in the coal measures of Nova Scotia," and in the writer's paper on the "Coal Measures of the South Joggins;"* while other important investigations grew out of the following up of these researches, and much matter in relation to the vegetable fossils still remains to be worked up. It is with the more striking fact of the discovery of the remains of a reptile in the coal measures that we have now to do.

The South Joggins Section is, among other things, remarkable for the number of beds which contain remains of erect trees imbedded *in situ:* these trees are for the most part Sigillariæ, varying in diameter from six inches to five feet. They have grown in underclays and wet soils, similar to those in which the coal was accumulated; and these having been submerged or buried by mud carried down by inundations, the trees, killed by the accumulations around their stems, have decayed, and their tops being broken off at the level of the mud or sand, the cylindrical cavities, left open by the disappearance of the wood, and preserved in their form by the greater durability of the bark, have been filled with sand and clay. This, now hardened into stone, constitutes pillar-like casts of the trees, which may often be seen exposed in the cliffs, and which, as these waste away, fall upon the beach. The sandstones enveloping these pillared trunks of the ancient Sigillariæ of the coal, are laminated or bedded, and the laminæ, when exposed, split apart with the weather, so that the trees themselves become split across; this being often aided by the arrangement of the matter within the trunks, in layers more or less corresponding to those without. Thus one of these fossil trees usually falls to the beach in a series of discs, somewhat resembling the grindstones which are extensively manufactured on the coast. The surfaces of these fragments often exhibit remains of plants which have been washed into the hollow trunks and have been imbedded there; and in our explorations of the shore, we always carefully scrutinized such specimens, both with the view of observing whether they retained the superficial markings of Sigillariæ, and with reference to the fossils contained in them. It was while examining a pile of these "fossil grindstones," that we were surprised by finding on one of them what seemed to be fragments of bone. On careful search other bones appeared, and they had the aspect, not of remains of fishes, of which many species are found fossil in these coal measures, but rather of limb-bones of a quadruped. The fallen pieces of the tree were carefully taken up, and other bones disengaged, and at length a jaw with teeth made its appearance. We felt quite confident, from the first, that these bones were reptilian; and the whole, being carefully packed and labelled, were taken by Sir Charles to the United States, and submitted to Prof. J. Wyman of Cambridge; who recognized their reptilian character, and prepared descriptive notes of the principal bones, which appeared to have belonged to two species. He also observed among the fragments an object of different character, apparently a shell; which was recognized by Dr. Gould of Boston, and subsequently by Mr. Deshayes, as probably a land-snail, and has since been named *Pupa vetusta.*

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* Journal of the Geological Society of London; Vols. ix and x; and Acadian Geology.

The specimens were subsequently taken to London and re-examined by Prof. Owen, who confirmed Wyman's inferences, added other characters to the description, and named the larger and better preserved species *Dendrerpeton Acadianum*, in allusion to its discovery in the interior of a tree, and to its native country of Acadia or Nova Scotia. With the aid of Plate III, I shall now endeavour to describe this species as fully as the materials at my command will allow, and shall then make some remarks on its affinities, habitat, and mode of life. It is necessary to state in explanation of the fragmentary character of the remains represented in the plate, that in the decay of the animals imbedded in the erect trees at the Joggins, their skeletons have become disarticulated, and the portions scattered, either by falling into the interstices of the vegetable fragments in the bottom of the hollow trunks, or by the water, with which these may have sometimes been partly filled. We thus can obtain only separate bones; and though all of these are no doubt present in each case, it is impossible in breaking up the hard matrix to recover more than a small proportion of them. For this reason I have been obliged to have recourse, not merely to the original specimen whose discovery is noticed above, but to three others subsequently obtained by me; all however belonging, on the evidence of the teeth and more important bones, to one species, and all being nearly, though not absolutely, of the same size. It is also proper to state that in the case of the original specimen, and another still more perfect one, both of which are now in London, I have been able to refer only to the published plates, and to add to these from parts of two additional individuals still in my own collection.

In form, *Dendrerpeton Acadianum* was probably lizard-like; with a broad flat head, short stout limbs and an elongated tail; and having its skin, and more particularly that of the belly, protected by small bony plates closely overlapping each other. It may have attained the length of two feet. The form of the head is not unlike that of *Baphetes*, but longer in proportion; and much resembles that of the labyrinthodont reptiles of the Trias (Fig. 1). The bones of the skull are sculptured as in *Baphetes*, but in a smaller pattern (Figs. 8, 9). The nostrils are small, and near the muzzle: the orbits are circular, and separated by a space of more than their own diameter. In the upper jaw there is a series of conical teeth on the maxillary and intermaxillary bones (Figs. 5, 15). Those on the intermaxillaries are much larger than the others, and have the aspect of tusks or canines (Figs. 3, 13). Within this outer series of teeth, and implanted apparently in palatal bones, as in *Archegosaurus Decheni*, there is a second series of teeth, closely placed, or with intervals equal to the diameter of one tooth. These inner teeth are longer than the others, implanted in shallow sockets, to which they are anchylosed, and have the dentine plicated, except toward the point (Figs. 2, 4, 6, 7, 17). A third group of teeth, blunt at the points, largely hollow in the interior, and with the dentine quite simple, appears in detached bones, which may represent the vomer (Fig. 12). Only a part of this formidable armature of teeth appears in the skull represented in Fig. 1, as the bones of the roof of the mouth have been removed, adhering to the opposite side of the matrix; but the fact of the occurrence of two sets of teeth was ascertained by Prof Wyman, from the original specimens, and is manifest in the fragment represented in Fig. 17; while the other teeth, supposed to be vomerine, appear in fragments which must, from their size and collocation, have belonged to *Dendrerpeton*. It will be observed that all these teeth are anchylosed to the bone; and while those of the vomer are thinly walled and simple, those on the maxillaries and intermaxillaries are plicated toward the base only, while the inner series of palatal teeth are plicated more than half way up. In the lower jaw there was a uniform series of conical teeth, not perceptibly enlarged toward the front; at least this is the case in the only specimen at present in my collection (Fig. 16); which is however merely an imperfect cast in hard sandstone.

The scapular and sternal bones seem to have been well developed and strong, but only portions of them are known (Fig. 25.) The fore limb of the adult animal, including the toes, must have been four or five inches in length, and is of massive proportions. The bones were hollow, and in the case of the phalanges the bony walls were thin, so that they are often found crushed flat. The humerus however was a strong bone, with thick walls and a cancellated structure toward its extremities; still even these have sometimes yielded to the great pressure to which they have been subjected. Fig. 26 shows the humerus of the original specimen of the species, and Fig. 10 exhibits a series of sections of a similar bone, probably the humerus of a smaller individual. The cavity of the interior of the limb-bones is usually filled with calc-spar stained with organic matter, but showing no structure; and the inner side of the bony wall is smooth, without any indication of cartilaginous matter lining it.

The vertebræ, in the external aspect of their bodies, remind one of those of fishes, expanding toward the extremities, and being deeply hollowed by conical cavities, which appear even to meet in the centre. There is however a large and flattened neural spine. The vertebræ are usually much crushed, and it is almost impossible to disengage them from the stone. Fig. 21 exhibits the usual form, and Fig. 22 another; which, in its long neural and hæmal spines, reminds us of the caudal vertebræ of those batrachians and reptiles which have tails flattened for swimming, and probably indicates that this was the case with *Dendrerpeton.* Fig. 23 is a transverse section of a somewhat crushed vertebra, showing its ossified centrum and neural spine, and also the microscopic structure of the bone. The ribs are long and curved, with an expanded head, near to which they are solid, but become hollow towards the middle; and the distal extremities are flattened and thin walled. The posterior limb seems to have been not larger than the anterior, perhaps smaller. The bones represented in Fig. 27, which I refer to this member, probably belonged to a somewhat smaller individual than that to which the humerus in Fig. 26 belonged. The tibia is much flattened at the extremity, as in some labyrinthodonts, and the foot must have been broad, and probably suited for swimming or walking on soft mud, or both. That the hind limb was adapted for walking is shown, not merely by the form of the bones, but also by that of the pelvis, the best preserved specimen of which is represented in Fig. 28 ; but an iliac limb of still larger size is figured in the Journal of the Geological Society, Vol. IX.

The external scales are thin, oblique-rhomboidal or elongated-oval, marked with slight concentric lines, but otherwise smooth, and having a thickened ridge or margin ; in which they resemble those of *Archegosaurus*, and also those of *Pholidogaster pisciformis*, recently described by Huxley from the Edinburgh coal-field,—an animal which indeed appears in most respects to have a close affinity with *Dendrerpeton.* The microscopic structure of the scales is quite similar to that of the other bones, and different from that of the scales of ganoid fishes, the shape of the cells being batrachian as in Fig. 11. Figs. 18 and 19 exhibit different forms of the scales.

With respect to the affinities of the creature, I think it is obvious that it presents some points of resemblance, on the one hand to *Archegosaurus*, and on the other, to *Labyrinthodon ;* and that it has the same singular mixture of ichthyic, batrachian, and reptilian characters which distinguish these ancient animals, and which give them the appearance of prototypes of the reptilian class. Professor Owen regards *Archegosaurus* as the type of the order *Ganocephala,* which he characterizes as having the head protected by sculptured and polished ganoid plates, no occipital condyles, teeth with converging folds of cement at their basal half, the notochord persistent, the ribs short and straight, the limbs natatory and small ; and holds that *Dendrerpeton* approaches more nearly to this order than to the *Labyrinthodonts.* But at the time when this opinion was expressed, he was not fully aware of the development of the limbs and ribs, and of the ossified condition of the vertebræ ; characters which, with the form of the skull, the arrangement of the teeth, and the probable possession of occipital condyles, appear to determine the scale in favour of the *Labyrinthodonts.* At the same time it must be admitted that *Dendrerpeton* is far removed from the typical genus *Labyrinthodon*, and that in the characters in which it differs, it leans toward *Archegosaurus;* closely resembling in this its contemporary *Pholidogaster pisciformis* already referred to.

This ancient inhabitant of the coal swamps of Nova Scotia, was, in short, as we often find to be the case with the earliest forms of life, the possessor of powers and structures not usually, in the modern world, combined in a single species. It was certainly not a fish, yet its bony scales, and the form of its vertebræ, and of its teeth, might, in the absence of other evidence, cause it to be mistaken for one. We call it a batrachian, yet its dentition, the sculpturing of the bones of its skull, which were certainly no more external plates than the similar bones of a crocodile, its ribs, and the structure of its limbs, remind us of the higher reptiles; and we do not know that it ever possessed gills, or passed through a larval or fish-like condition. Still, in a great many important characters, its structures are undoubtedly batrachian. It stands, in short, in the same position with the *Lepidodendra* and *Sigillariæ* under whose shade it crept, which though placed by palæo-botanists in alliance with certain modern groups of plants, manifestly differed from these in many of their characters, and occupied a different position in nature. In the coal period, the distinctions of physical and vital conditions were not well defined—dry land and water, terrestrial and aquatic plants and animals, and lower and higher forms of animal and vegetable life, are consequently not easily separated from each other. This is no doubt a state of things characteristic of the earlier stages of the earth's history, yet not necessarily so; for there are some reasons, derived from fossil plants, for believing that in the preceding Devonian period there was less of this, and consequently that there may then have been a higher and more varied animal life than in the coal period.* Even in the modern world also, we still find local cases of this early union of dissimilar conditions. It is in the swamps of Africa, at one time dry, at another inundated, that such intermediate forms as *Lepidosiren* occur, to baffle the classificatory powers of naturalists; and it is in the stagnant unaerated waters, half swamp, half lake or river, and unfit for ordinary fishes, that the semi-reptilian *Amia* and *Lepidosteus* still keep up the characters of their palæozoic predecessors.

The dentition of *Dendrerpeton* shows it to have been carnivorous in a high degree. It may have captured fishes and smaller reptiles, either on land or in water, and very probably fed on dead carcases as well. If, as seems likely, the footprints referred to in a previous section belong to *Dendrerpeton*, it must have frequented the shores, either in search of garbage, or on its way to and from the waters. The occurrence of its remains in the stumps of Sigillaria, with land-snails and millipedes, shows also that it crept in the shade of the woods in search of food; and under the head of coprolitic matter, in a subsequent section, I shall show that remains of excrementitious substances, probably of this species, contain fragments, attributable to smaller reptiles, and other animals of the land.

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* See the author's paper on Devonian plants, Journal of the Geological Society, Vol. xviii, p. 328.

All the bones of *Dendrerpeton* hitherto found, as well as those of the smaller reptilian species hereafter described, have been obtained from the interior of erect Sigillariæ, and all of these in one of the many beds, which, at the Joggins, contain such remains. The thick cellular inner bark of Sigillaria was very perishable; the slender woody axis was somewhat more durable; but near the surface of the stem, in large trunks, there was a layer of elongated cells, or bast tissue, of considerable durability, and the outer bark was exceedingly dense and indestructible.* Hence an erect tree, partly imbedded in sediment, and subjected to the influence of the weather, became a hollow shell of bark; in the bottom of which lay the decaying remains of the woody axis, and shreds of the fibrous bark. In ordinary circumstances such hollow stems would be almost immediately filled with silt and sand, deposited in the numerous inundations and subsidences of the coal swamps. Where however they remained open for a considerable time, they would constitute a series of pitfalls, into which animals walking on the surface might be precipitated; and being probably often partly covered by remains of prostrate trunks, or by vegetation growing around their mouths, they would be places of retreat and abode for land-snails and such creatures. When the surface was again inundated or submerged, all such animals, with the remains of those which had fallen into the deeper pits, would be imbedded in the sediment which would then fill up the holes. These seem to have been the precise conditions of the bed which has afforded all these remains. I may add that I believe all the trees, four or five in number, which have become exposed in this bed since its discovery, have been ransacked for such remains; and that while all have afforded some reward for the labour, some have been far more rich than others in their contents. It is also to be observed that owing to the mode of accumulation of the mass filling the trees, the bones are usually found scattered in every position, and those of different species intermingled; and that being often much more friable than the matrix, much labour is required for their development; while after all has been done, the result is a congeries of fragments like that presented by Plate III. The two specimens which displayed the largest number of bones in juxtaposition, are one of *Dendrerpeton Acadianum*, and one of *Hylonomus Lyelli*, both presented by me to the geological Society of London, and now in its collection; but of which I shall endeavour to obtain accurate representations for this memoir.

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* See a paper by the author, on the structures of coal; Journal of the Geological Society, Vol. xv; also supplement to Acadian Geology.

In order more fully to illustrate the mode of occurence of these remains, I quote the following notice of my last explorations in the bed containing them, from the Journal of the Geological Society of London, for 1861:

" In the bed which has hitherto alone afforded reptilian remains in its erect trees, two additional examples of these were exposed. One was on the beach, and in part removed by the sea. The other was in the cliff, but so far disengaged that a miner succeeded in bringing it down for me. In the first, comparatively little was found. It afforded only a few shells of *Pupa vetusta*, and scattered bones of a full-grown individual of *Dendrerpeton Acadianum.*

" The second tree was more richly stored; and, being *in situ*, was very instructive as to the mode of occurence of the remains. Like all the other trees in which reptilian bones have been found, it sprang immediately from the surface of the six-inch coal in Group XV. of my section*; which is also Coal No. 15 of Sir W. E. Logan's section†. Its diameter at the base was two feet, and its height six feet, above which, however, an appearance of additional height was given by the usual funnel-shaped sinking of the overlying beds toward the cavity of the trunk. The bark is well preserved in the state of bituminous coal, and presents externally a longitudinally wrinkled surface, without ribs or leaf-scars; but within, on the 'ligneous' surface, or that of the inner bark, there are broad flat ribs, and transversely elongated scars. The appearances are precisely those which might be expected on an old trunk of my *Sigillaria Brownii*; to which species this tree may have very well belonged.‡

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* Quart. Journ. Geol. Soc. Vol. ix. p. 58, and Vol. x. p. 20.

† Reports of Geol. Survey of Canada, 1845.

‡ Quart. Journ. Geol. Soc. Vol. xvii. p. 523.

"The contents of the trunk correspond with those of others previously found. At the bottom is the usual layer of mineral charcoal, consisting of the fallen wood and bark of the tree itself. Above this, about two feet of its height are filled with a confused mass of vegetable fragments, consisting of *Cordaites*, *Lepidodendron*, *Ulodendron*, *Lepidostrobus*, *Calamites*, *Trigonocarpum*, stipes and fronds of ferns, and mineral charcoal; the whole imbedded in a sandy paste blackened by coaly matter. In, and at the top of this mass occur the animal remains. The remainder of the trunk is occupied with grey and buff sandstone, containing a few fragments of plants, but no remains of animals.

"Portions of six reptilian skeletons were obtained from this trunk. The most important of these is a large and nearly complete skeleton of *Dendrerpeton Acadianum*.* Another specimen found in this trunk is a jaw of an animal about the size of *Dendrerpeton Acadianum*, but with fewer and larger teeth.† The remaining skeletons were imperfect, and belonged to a small individual of *Dendrerpeton Acadianum*, two of *Hylonomus Lyelli*, and one of *Hylonomus Wymani*. The dislocated condition of these and other skeletons is probably due to the circumstance that, when they were introduced, the matter filling the trunk was a loose mass of fragments, into the crevices of which the bones dropped, on decay of the soft parts. Most of the skeletons lie at the sides of the trunk, as if the animals had before death crept close to the walls of their prison. At the time when the reptiles were introduced, the hollow trunk must have been a pit four feet in depth. A number of specimens of *Pupa vetusta* and *Xylobius Sigillariæ* were found, but nothing throwing further light on these species.

"The beds on a level with the top of this erect tree are arenaceous sandstones, with numerous erect *Calamites*. I searched the surfaces of these beds in vain for bones or footprints of the reptiles which must have traversed them, and which, but for the hollow erect trees, would apparently have left no trace of their existence. On a surface of similar character, sixty feet higher, and separated by three coals, with their accompaniments, and a very thick compact sandstone, I observed a series of footprints, which may be those of *Dendrerpeton* or *Hylonomus*."

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* Now in the collection of the Geological Society of London. Fig. 1, represents the skull of this specimen.

† Since named and described by Prof. Owen as *Hylerpeton Dawsoni*.

EXPLANATION OF PLATE I.

Footprints of Reptiles, &c.

Fig. 1.—Footprints discovered by Sir W. E. Logan, in the Lower Carboniferous beds of Horton Bluff, in 1841; reduced to one-fourth of the natural size. (1a) one of the impressions, natural size.

" 2.—Footprints discovered by Dr. Harding, in the Lower Carboniferous beds of Parrsboro'; one-fourth of the natural size. (2a) Prints of fore and hind foot, natural size. This figure is from a rubbing kindly taken for me by Prof. How, of Windsor.

" 3.—Footprints from the Coal Measures of the South Joggins; one-fourth natural size. (3 a) One of the impressions, natural size.

" 4.—Smaller footprints from the South Joggins; one-fourth of natural size.

" 5.—Skin of a reptile, found with remains of a small *Dendrerpeton*, in an erect tree at the Joggins. (a) Scaly portions; (b) Traces of hind leg? and small scales. (c) (d) Portions magnified, showing scales.

EXPLANATION OF PLATE III.

Dendrerpeton Acadianum.

Fig. 1.—Skull seen from below.

" 2.—Inner tooth, magnified; from the jaw, Fig. 17.

" 3.—Tooth of intermaxillary, magnified; from the bone in Fig. 13.

" 4.—Series of inner teeth, less magnified.

" 5.—Series of outer teeth of maxillary bone, Fig. 15, magnified.

" 6, 7.—Sections of inner teeth.

" 8.—Portion of bone of skull, outer surface, twice the natural size.

" 9.—Super-temporal bone, twice the natural size.

" 10.—Cross section of humerus; (a) natural size; (b) magnified; (c) portion more highly magnified, showing canals and bone cells.

" 11.—Bone cells, highly magnified.

" 12.—Vomer? with teeth; (a) tooth magnified.

" 13.—Intermaxillary with teeth.

" 14.—Section of teeth of intermaxillary; (b) magnified; (a) portion highly magnified.

" 15.—Maxillary bone with teeth.

" 16.—Mandible with teeth.

" 17.—Fragment of skull, with (a) outer teeth of maxillary; (b) inner palatal teeth.

" 18.—Cross section of a scale, magnified.

Fig. 19.—Outlines of scales, natural size.
" 20.—Scale, twice natural size.
" 21.—Vertebra.
" 22.—Caudal vertebra.
" 23.—Vertebra broken across, showing neural and central cavities; (a) natural size; (b) section of a portion magnified, showing canals and bone cells.
" 24.—Fragments of ribs.
" 25.—Scapular bone.
" 26.—Humerus, crushed at the proximal end, with fragments of the radius.
" 27.—Fragments of femur, tibia, and fibula.
" 28.—Remains of pelvis.
" 29.—Bones of the foot.
" 30.—Group of bones of the foot, *in situ*.

All the above are of the natural size, unless otherwise stated.

ART. VII.—*Notes on Diatomaceæ from the St. John River*; by PROF. L. W. BAILEY, of the University of New Brunswick.

(Communicated by the Natural History Society of New Brunswick.)

For the benefit of those especially interested in such pursuits, I have prepared the following lists of the species which I have, so far, observed as occurring in the waters of this Province. Further study will no doubt add greatly to the number of species.

The first list which I have to present is that of a number of forms obtained from a very interesting gathering, kindly sent me by Mr. G. F. Matthew, a member of the Society, with the request, that I would report any results which might occur to me. The examination has been to me one of much pleasure, and has developed facts of importance in regard to the distribution of the species it contains. Although I give the list so far as now completed, I hope to be able, at some future period, to dwell at more length upon the subject, and at the same time to present a variety of other interesting matter from various parts of the province.

List of Diatomaceæ from Harris' Cove, Kennebeckasis R., N. B.

Doryphora Boeckii.
" *amphiceros.*
Navicula maculata, Bail.
" *ovalis.*
" *viridis.*
" *rhynchocephala.*
Navicula pusilla ?
" *permagna.*
" *firma.*
Pinularia major.
" *Couperi ?*
" *mesolepta.*

Pleurosigma strigilis.
" *intermedium.*
" *Spencerii*
Nitzschia scalaris.
" *dubia.*
" *sigmoidea.*
Tryblionella gracilis.
" *scutell.*
" *punctata.*
Epithemia turgida.
" *musculus.*
" *granulata.*
" *gibba.*
Campylodiscus Argus.
Surirella biseriata.
" *circumsuta.*
" *splendida.*
" *linearis.*
" *ovata.*
" *limosa.*
Amphiprora alata.
Coscinodiscus minor.
" *cingulatus ?*
" *radiatus.*
Coscinodiscus eccentricus.
" ———
Eupodiscus radiatus ?
Biddulphia turgida.
Cocconema lanceolata.
Gomphonema geminatum.
" *acuminatum.*
Striatella unipunctata.
Orthosira orichalcea.
Melosira Borrerii.
Podosira hormoides.
Achnanthes.
Synedra undulata.
" *radians.*
Cymbella cuspidata.
Mastogloia.
Podosphenia.
Stauroneis gracilis.
" *salina.*
Triciratium.
Amphora ovalis.
Eunotia Arcus.
Cyclotella Kützingiana.
Himantidium.

From this one locality therefore may be procured as many as thirty distinct genera, and not less than sixty species. Long before receiving the above gathering, I had considered it probable that an examination of the aquatic flora in the lower portion of the St. John River would yield interesting results, from the very unusual connexion between that stream and the ocean. As will be seen by an examination of the above list, this conjecture has been verified, the gathering containing a curious mixture of fresh-water, marine, and brackish-water species. It will be an interesting point to determine how far up this influence of the salt water, may extend ; marine species being in many cases found many miles above the faintest suspicion of salt-water.

If, as is generally supposed, the three great parallel sheets of water, which cross the southern central portion of the Province, viz, the Kennebecasis, Long Reach, and Grand Lake, are really the remains of three or more great central lakes left by the rising of the land above the ocean, and connected with each other and the sea by the breaking away of the rocky barriers at their south-west extremities, we would expect to find some remains of marine vegetation among the marls and alluvial clays which line their banks. The subject is one of much interest, and one to which I shall continue to devote myself as opportunities offer.

As far as I am aware the above list is the only one yet published concerning the microscopic organisms of this Province: indeed I think it doubtful whether any one has hitherto even examined our microscopic flora. The list is at present an imperfect one, and will be undoubtedly increased by farther observation. It may, however be taken as a very fair list of the characteristic diatomaceous forms from the lower St. John. I have not yet had the opportunity to make examinations of gatherings from other portions of the stream. A few forms however, collected, from the surface of stranded ice during the opening of the river last Spring, may be interesting, and are given below. The number of all of these were very great; comparatively few different species were detected. They were as follows:

Organisms observed in melting ice of St. John River.

Fragilaria capucina.
Tabellaria flocculosa.
Cymbella Helvetica.
Odontidium mesodon.

Eunotia monodon.
" *Arcus.*
Cocconema lanceolatum.
Nitzschia Amphioxys.
Surirella
Gomphonema geminatum.
" *accuminatum.*
Synedra Ulna.
Pinnularia mesolepta.

The following forms, including Desmids, Diatoms, and Infusoria, were found in a small pond upon the summit of the hill back of the University buildings, at Fredericton.

Euastrum.
Micrasterias crenata.
" *denticulata.*
= *Rota.*
Didymocladon.
Closterium.
Meridion circulare.
Volvox globater.

I had hoped in the present article to bring before the Society the economic importance of these microscopic organisms, and more especially the assistance they will eventually afford in the determination of the age of many geological deposits from which all traces of organic life have disappeared. This is a particularly interesting subject, and one on which I hope to bring forward some new facts. As the discussion however is necessarily a lengthened one, and as the time at my disposal is now too limited to do the subject full justice, I must beg leave to postpone the remainder to some future period. I shall then attempt to discuss this important question, and at the same time to report the examinamination of other localities from various parts of the Province. In conclusion, I will only say, that specimens of algæ, especially of lighter kinds from the shores of the Bay of Fundy, or Gulf of St. Lawrence, would be highly prized by me, if any members have the means of obtaining them, and could not fail to furnish much that would be new and interesting in the study of our Microscopic Flora.

Note.—Harris' Cove is about thirteen miles from the outlet of Kennebeckasis Bay, and three miles from its head. As the streams which enter this arm of the lake at the mouth of the Saint John River, are all of small size, the salt water which flows inward at flood-tide over the Falls, or rapids connecting it with the harbour, has free access to the locality where those organisms were obtained.

The water is not so brackish however, as to prevent the growth of Potamogeton perfoliatus, Potamogeton pectinatus, Nuphar lutea, confervæ and other aquatic plants; which by their luxuriant growth choke the shallow waters of this and other coves in Kennebeckasis Bay, and are frequently uncovered during the low stage of the river, at midsummer. During the freshets of early spring the salt water is for a time completely excluded by the floods poured into this lake-like expansion of the river, by the main St. John.

ART. VIII.—*Description of a new Trilobite from the Quebec group;* by T. DEVINE, F.R.G.S., C. L. Dept. Quebec.*

OLENUS ? LOGANI. (N. sp.)

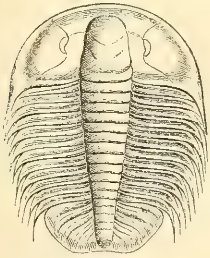

Fig. I.

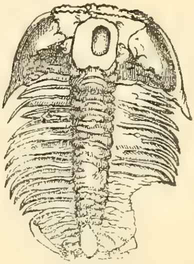

Fig. II.

Fig. I.—*O. Logani.* The anterior point of glabella in this figure is slightly too narrow.

Fig. II.—An imperfect specimen shewing the hypostoma in place.

The general form is oval.

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* NOTE.—By E. Billings. Mr. Devine having lately discovered several nearly perfect trilobites in the limestone at Point Lévis, has kindly

HEAD—exclusive of spines, semi-circular, more than twice as wide as long; truncate in front, and prominently convex in the middle, with a narrow equal border one half a line in width, extended at the posterior angles with the free cheeks into moderate diverging spines; posterior margin marked by a shallow furrow, reaching from the glabella outward to the free cheeks; eyes not large, smooth, and equi-distant from the front and posterior margins, and about one line from the glabella; the ocular ridge prominent, extending from the eye obliquely forward to the glabella, meeting the latter at about one line from the front thereof; facial suture running obliquely from the eye, and cutting the front and posterior margins far outward. The free cheeks are not quite so smooth as the central lobe of head, but no radiation or other marking is visible.

GLABELLA—bell-shaped; width less than one third of the entire head; broadly rounded in front, reaching nearly to the

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consented to allow me to publish a note on them in this place. The species is unquestionably congeneric with those which I have called *Dikelocephalus Belli* and *D. Oweni* from the same locality. My references were founded on fragments of the head, consisting of detached glabellæ, but the aspect presented by these new specimens, (which exhibit all the parts) is that of the genus *Olenus*. As the structure of the underside of the head is unknown, it cannot yet be positively decided that this species truly belongs to that genus, but it is the best reference that can at present be made, and was Mr. Devine's first conclusion. There are two points of difference that are worthy of notice. In *Olenus* (at least in all the 21 species figured by Angelin), the facial sutures run from the eyes either nearly straightforwards, or turn a little inwards. In this species they curve outwards. This is their course in *Dikelocephalus*. The eyes also in *Olenus* are, in general much more distant from the sides of the glabella than they are in this species. Should the underside of the head of the Swedish species of *Olenus* and of *O. Logani* turn out to be the same in structure, then no one would hesitate to place them all in the same genus. In *Dikelocephalus Oweni* the head is composed of three pieces only: 1.—The glabella with the fixed cheeks. 2.—The hypostoma. 3.—The two movable cheeks which are united together by a band extending across the front margin on the underside of the head. I think it will turn out that *O. Logani* is of the same structure.

Angelin has described the Swedish species of *Olenus* under eight subgenera and Mr. Devine's species might form the type of a ninth, differing as much from them, as they do from each other. His discovery is an important addition to our knowledge, as we now know (from entire specimens) that the genus *Dikelocephalus*, so characteristic of the base of the palæozoic rocks of America, is closely allied to the genus *Olenus*.

front margin; straight sides converging a little anteriorly, convex towards the front; depressed convex at the neck lobe; neck furrow well defined, extending across, and directed obliquely forward at each side—two oblique glabellar furrows at each side in front of the latter, making an angle anteriorly of about 45° with the axis; the furrows are well marked interiorly but very obscure at the sides, and are separated by about one half the width of the glabella, forming three lateral lobes of nearly equal size, each larger than the neck lobe. In some specimens there are three glabellar furrows on each side, the front one making a greater angle anteriorly with the axis than either of the others.

Pleuræ—twelve; moderately convex outward from the axal furrow, each marked by an equal deep groove to the tips, which are of a horny aspect, recurved and extended into long spines; sides parallel as far back as the eighth segment, then gradually converging to the pygidium.

Axis—convex, gradually tapering to the extremity of the tail, about two thirds of the width of the pleuræ anteriorly—less at the pygidium; twelve body rings, and five or six caudal joints; the body rings notched above posteriorly and slightly swelled at the axal furrows.

Pygidium—entire; semi-circular; truncate behind; lateral lobes depressed convex, on a level with the pleuræ; four broad ribs on each side of the middle lobe recurved towards the extremities; margin smooth, and entire anterior angles moderately rounded.

Dimensions of largest specimen.

Entire length	16	lines.
Length of head	5	“
“ of thorax	8	“
Axis of tail	3	“
Width at base of head	11	“
“ at eighth segment	10	“
“ at front of pygidium	8	“
“ of axis at same place	1½	“
Length of glabella	4	“
Width at neck lobe	3⅓	“
“ at front of glabella	2½	“
“ between the eyes	4	“
“ of margin in front of glabella	0½	“
“ of border	0½	“

Locality, Point Levis.—Band of limestone, A3, referred to in Sir W. E. Logan's "Remarks on the Fauna of the Quebec group of Rocks and the Primordial Zone of Canada," addressed to Mr. J. Barrande, dated Montreal, 31st Dec. 1860, and printed in the Canadian Naturalist and Geologist of that year.

I have in the mean time referred this species to *Olenus*, although at one time inclined to refer it to *Conocephalites*, (Sub-genus). Should it be found necessary to institute an intermediate generic form, whatever place Naturalists may assign it in the animal kingdom, I propose that it be named *Loganellus Quebecensis.*

Dedicated to Sir W. E. Logan, F. R. S. &c., &c.,
Director of the Canadian Geological Survey.

Art. IX.—*On the Land and Fresh-water Mollusca of Lower Canada ;* by J. F. Whiteaves, F.G.S., &c.

(*Read before the Natural History Society of Montreal.*)

Part II.—List of Species Inhabiting Lower Canada.

The writer of this list wishes to acknowledge his obligations to many of the most eminent United States conchologists for practical suggestions and assistance. Mr. Temple Prime has kindly indentified the Cycladidæ; The writer is also indebted to Messrs. Bland, Binney, J. G. Anthony, I. Lea, A. D. Brown, Tryon, and others, for critical advice and sympathy.

In the nomenclature of the Unionidæ, the names given by Rafinesque have been retained; these having priority. The writer has been unable to see why Lamarck's short, insufficient diagnoses of species in this difficult family, should be preferred to the exclusion of the earlier descriptions of the author of " the Bivalve Shells of the Ohio River."

As the Lower Canadian Cycladidæ seem very little understood, Mr. Prime's careful descriptions of these somewhat intricate shells have, with his consent, been added; together with wood-cuts, taken from original drawings.

Note.—The following abbreviations have been made use of in citing the authority for each species in Lower Canada : —R. B. (R. Bell) : W. D. (W. D'Urban) : E. B. (E. Billings) : R. J. F. (R. J. Fowler) : J. F. W. (J. F. Whiteaves) : W. C. (W. Couper) M. de V. (M. de Villeneuve).

LAMELLIBRANCHIATA.

UNIONIDÆ.

Unio radiatus, Lamarck. Abundant in the rivers and lakes of Canada East. The U. siliquoideus is often taken for this shell.

Unio siliquoideus, Barnes. Equally common with the above. For details of difference between the former species and this, see Conrad's Monograph of the genus Unio. As many able conchologists deny that this is the Unio luteolus of Lamarck, I have preferred keeping the name given to the species by Barnes.

Unio Canadensis, Lea. St. Helen's Island, Montreal; apparently very rare. Some rayed specimens of a Unio which I took at Quebec may be a dwarf form of this species. A single dead *typical* specimen on the beach of the Island of Orleans: J. F. W.

Unio cardium, Rafinesque. (U. ventricosus, Barnes.) St. Lawrence; very fine near Quebec. Unio subovatus, Lea, appears to be the male of this species; and U. occidens, Lea, a variety of the female.

Unio complanatus, Solander. By far the commonest Unio in the district; living (according to Mr. Bell) as far down the St. Lawrence as Berthier below Quebec.

Unio dilatatus, Rafinesque. (U. gibbosus, Barnes.) Widely distributed in the St. Lawrence and its tributaries, but scarce. Some varieties closely resemble the last species.

Unio rectus, Lamarck. St. Lawrence at Quebec and Montreal, but somewhat rare.

Unio alasmodontinus, Barnes, (U. pressus, Lea.) Rare: L'Assomption river: M. de V. River St. Pierre, and Lachine canal near Montreal: R. J. F. Rideau canal near Ottawa city: E. B.

Unio alatus, Say. Ottawa river, near Ottawa: mouth of River Rouge: R. B.

Unio olivarius, Rafinesque. (U. ellipsis, Lea, *fide* J.G. Anthony.) St. Lawrence at Quebec and Montreal; fine and not infrequent at Quebec.

Margaritana margaritifera, Linn. (Alasmodon arcuatus, Barnes.) Very large and fine in the St. Charles river near Quebec: J. F.W. Green and Rimouski rivers; both of the Matapedia lakes; Lake St. John: R. B.

Margaritana costata, Rafinesque. (Alasmodon rugosa, Barnes.) Sparingly in the St. Lawrence about Montreal. Yamaska river near St. Hyacinthe: J. F. W.

Margaritana marginata, Say. With the foregoing, but not very common.

Margaritana undulata, Say. Common in the St. Lawrence down to Quebec; at which latter place it is very abundant, and often beautifully coloured.

Anodonta cataracta, Say. (A. fluviatilis, Lea.) Lake Calvaire, near Quebec: abundant in small creeks near the St. Charles river at Quebec: J. F. W. Large and plentiful at Brome Lake in the Eastern Townships: R. J. F. Probably common in suitable places throughout the district.

Anodonta Lewisii, Lea. Lachine canal near Montreal. R. J. F.

Anodonta Benedictensis, Lea. Mississquoi bay, Lake Champlain.

Anodonta implicata, Say. Fine in the St. Lawrence near Quebec: J. F. W. Berthier: R. B.

Anodonta Ferussaciana, Lea. Creek at L'Orignal: R. B. Fine in old stone quarries near the Mile-end toll-gate, Montreal.

Anodonta undulata, Say. St. Charles river about three miles from Quebec.

Anodonta edentula, Say. Lake Matapedia: R. B. Brome Lake in the Eastern Townships: R. J. F. I consider this species, and perhaps even the next, as identical with A. undulata, Say.

Anodonta subcylindracea, Lea. Lachine Canal: R. J. F. St. Lawrence at Quebec. J. F. W.

Anodonta Footiana, Lea. Sixteen Island, Eagle Nest, and Bevan's lakes. W. D.

Anodonta modesta? Lea. A few specimens which appear to me to agree with Mr. Lea's figures and description of this species, were taken by Mr. Bell from Lake St. John.

CYCLADIDÆ.

The genus Cyclas was proposed by Bruguière in the year 1792; but Scopoli's genus Sphœrium bears date 1777; and consequently has priority, as has been shown by Dr. Gray. See Mr. Temple Prime's elaborate monograph of the North and South American species in this genus, published in the "Proceedings of the Academy of Natural Sciences of Philadelphia" for December, 1861.

Sphœrium sulcatum, Lamarck. (Cyclas similis, Say.) Metis lakes, and a small lake six miles S.W. of Metis: R. B. Common in the St. Lawrence at Montreal; and probably widely diffused throughout the province.

Sphœrium solidulum, Prime. Creek at L'Orignal: R. B. It will probably be detected in Canada East, as it has been taken so near the border.

Sphœrium striatinum, Lamarck. (Cyclas edentula, Say.) Lachine Canal, near Montreal: R. J. F. St. Lawrence and St. Charles rivers near Quebec, abundant: J. F. W.

Sphœrium rhomboideum, Say, (sp.). Gregarious, but very local. Old quarries near the Mile-end toll-gate, Montreal, but apparently confined to a very limited space there. R. J. F., and J. F. W.

Sphœrium occidentale, Prime. Swamps on an island near Lachine: R. J. F.

Sphœrium transversum, Say, (sp.). Lachine Canal near Montreal: R. J. F. St Lawrence near Quebec: J. F. W.

Sphœrium securis, Prime. Old stone quarries filled with water, near the Mile-end toll-gate, Montreal: R. J. F. and J. F. W. Lachine: R. J. F.

Pisidium Virginicum, Brongniart. (Cyclas dubia, Say.) St. Lawrence and St. Charles rivers at Quebec: J. F. W. Montreal, in the St. Lawrence, and the Lachine canal. Probably common in all the large tributaries of the St. Lawrence.

Pisidium altile, Anthony. Fine in the ponds near the Mile-end, Montreal: R. J. F., and J. F. W. A smaller, more compressed variety abounds in the St. Charles River near Quebec; J. F. W. It is the P. compressum of Prime; but Mr Anthony's name seems to have priority.

Pisidium abditum, Haldeman. A very common species in Lower Canada. I cite four localities where I have taken it, as examples. Swamps in woods near the St. Charles river, Quebec: trenches in fields near the Beauport road: marshy ground on the Plains of Abraham,—both near Quebec. Brook near river St. Pierre, Montreal.

GASTEROPODA,—PECTINIBRANCHIATA.

VIVIPARIDÆ.

Paludina decisa, Say. Common throughout the district. Reversed varieties occasionally occur in the St. Lawrence, about Montreal.

Valvata tricarinata, Say. Also abundant. At Quebec the species generally occurs large, with the carinæ sometimes almost obsolete.

Valvata sincera, Say. Marl lake, Anticosti : R. B.

Valvata humeralis, Say. This species, so closely allied to the depressed form of the V. piscinalis of Europe, has been taken by Mr. Bell at the following localities : Matanne; small lake at the head of Awaganasees brook, and Little Lake Matapedia.

Amnicola porata, Say. Lake Calvaire, near Quebec : J. F. W. Little Lake Matapedia : R. B. Near Montreal : R. J. F.

Amnicola tenuipes, Haldeman. St. Lawrence, near Quebec : burrowing in the sand between tide-marks : J. F. W.

MELANIADÆ.

Melania subularis, Lea. (M. acuta, Lea.) St. Lawrence at Montreal.

Melania Niagarensis, Lea. St. Lawrence, from Quebec to Montreal. At Quebec I obtained only the pale yellowish, unbanded variety.

GASTEROPODA,—PULMONIBRANCHIATA.

LIMNÆIDÆ.

Limnœa stagnalis, Linnæus. (L. jugularis, Say.) Common at Montreal in the St. Lawrence, but rare at Quebec. Metis lakes, and lakes on the Rimouski river : R. B. Probably of wide distribution in Canada East.

Limnœa megasoma, Say. Very fine at Nuns' Island, near Montreal : M. de V., and R. J. F. Hawkesbury village : R. B.

Limnœa ampla, Mighels. This fine species was first detected in Lower Canada by R. J. F. at Brome Lake.

Limnœa decollata, Mighels. Great Lake Matapedia, and Rimouski village : R. B.

Limnœa columella, Say. St. Lawrence at Quebec, adhering to stones at low water-mark : J. F. W. The var. macrostoma occurs with the type.

Limnœa reflexa, Say. Upper Metis Lake : R. B. Near Grenville village : W. D.

Limnœa umbrosa, Say. Point Levis : J. F. W. Montreal

Mountain: St. Anne: creek about two miles below Chat river: Metis and Restigouche rivers: R. B.

Limnœa elodes, Say. (L. palustris? Linn.) Common everywhere throughout the district. Haldeman in his monograph considers it the L. fragilis of Linnæus. In Europe L. fragilis is considered a variety of L. stagnalis, Linn., and the L. elodes of Say as probably identical with the L. palustris.

Limnœa catascopium, Say. A common species. As unpublished localities, I may cite the St. Charles river near Quebec, and Cap Rouge in the same neighborhood. Dr. Lewis of Mohawk (N.Y.) considers it a variety of the preceding shell.

Limnœa solida, Lea. (L. apicina, Lea: *fide* Haldeman.) Profusely abundant everywhere about the St. Lawrence at Quebec. Metis, Rimouski, and White rivers: R. B.

Limnœa caperata, Say. Widely distributed. Abundant with Succinea ovalis, Say, on the banks of the St. Charles river, near Quebec. Limnæa umbilicata, Adams: is generally considered a variety of this species.

Limnœa humilis, Say. (L. modicellus, Say.) Green Island village: Rimouski: St. Anne: R. B. Lake Calvaire near Quebec: and ponds near the Mile-end toll-gate, Montreal: J. F. W. L. parva, Lea, is supposed by Haldeman to be the young of this species.

Limnœa desidiosa, Say, (L. acuta and L. Philadelphica, Lea: *fide* Haldeman.) Upper Lake Metis: Marl lake, Anticosti: (the var. acuta): R. B.

Limnœa pallida, Adams. Great Lake Matapedia: Cape Chat: R. B.

Limnœa alternata (or a new species). Point Levis: R. B. A species which I am unacquainted with.

Limnœa exigua, Lea: (young). In a small lake near Hamilton's farm: W. D.

Limnœa galbanus, Say. Abundant in shell-marl from the bottom of Eagle's Nest lake: W. D.

Physa heterostropha, Say. Common everywhere throughout the district.

Physa ancillaria, Say. St. Charles river near Quebec: J. F. W. near Montreal: R. J. F. Rimouski village: R. B. Doubtful if distinct from the preceding.

Physa marginata, Lea. (not of Say.) Near Rimouski village. Probably a variety of P. heterostropha.

Physa hypnorum, Linn. (P. elongata, Say.) Abundant about Quebec and Montreal. Green Island: Metis: St. Anne: R. B.

Physa aurea, Lea. Several localities in the county of Rimouski: R. B. Near Quebec: J. F. W.

Physa elliptica, Lea. Small lake one mile west of the Indian village in Arundel: W. D.

Planorbis macrostomus, nobis. (see description, and Figure 12.) Ponds near the Mile-end toll-gate, Montreal: R. J. F., and J. F. W.

Planorbis trivolvis, Say. Common throughout the district. Planorbis corpulentus of Say appears to be a variety of this species.

Planorbis lentus, Say. Less frequent than the above. St. Lawrence at Montreal. An almost hyaline variety occurs with the normal form.

Planorbis bicarinatus, Say. Abundant apparently all through the province. Extremely large at Brome Lake, R. J. F. At Quebec a variety with transverse wrinkles, and the upper carina almost obsolete (P. megastoma ? De. Kay.) is more abundant than the type.

Planorbis campanulatus, Say. Near Quebec: J. F. W.: Fine at Brome Lake: common in the Richelieu River at St. Johns: St. Helen's Island, Montreal: R. J. F. Near Grenville, and in numerous lakes throughout that district. W. D.

Planorbis exacutus, Say . Scarce: swamps near the City mills, Montreal: R. J. F.

Planorbis deflectus, Say. Near Quebec: J. F. W. Great Lake Matapedia: R. B. Sixteen-Island and Sugar-bush lakes: W. D.

Planorbis parvus, Say. Widely distributed, and plentifu throughout the district.

Planorbulina armigera, Say. (sp.) Trenches in fields near the Beauport road, Quebec: J. F. W., and W. Couper: Nuns' Island, Montreal: R. J. F. Ponds on the top of Montreal Mountain: R. B.

Ancylus fuscus ? Adams. Ponds near the Mile-end toll-gate, Montreal: R. J. F., and J. F. W.

Ancylus rivularis ? Say. St. Lawrence, at Quebec and Montreal: St. Charles river near Quebec. Not having access to Haldeman's monograph of this genus, I am uncertain about these two species. The last may be A. parallelus, Haldeman.

GASTEROPODA,—PULMONIBRANCHIATA.

HELICIDÆ.

Tebennephorus Carolinensis, Bosc. Point Levis, large and fine: probably common in wooded districts.

Limax campestris? Gould. Abundant under stones in fields: also in woods.

Vitrina limpida, Gould. (=V. pellucida;) Montreal Mountain, abundant: R. J. F., and J. F. W. Rivière du Loup: R. B. and J. F. W. Trois Pistoles: St. Anne: Restigouche river, ten miles above its junction with the Matapedia: R. B.

Succinea obliqua, Say. Abundant everywhere, but generally in dryer situations than most North American Succineas.

Succinea ovalis, Gould. Banks of the St. Charles river near Quebec: J. F. W. Metis, Matanne, and St. Anne: R. B.

Succinea avara, Say. Island of Orleans; J. F. W.

Succinea vermeta, Say. Mouth of the Magdalen and Restigouche rivers: R. B. As many conchologists consider this a distinct species from the preceding, in deference to their opinion I keep them separate.

Helix albolabris, Say. Fine and frequent throughout the district: Mr. Bell appears, however, not to have met with it in the county of Gaspé.

Helix dentifera, Binney. St. Lambert, Montreal: near Brome Lake: R. J. F. Apparently very rare in Lower Canada.

Helix exoleta, Binney. About the Montmorenci river, near the falls: W. C., and J. F. W. Wentworth, Montcalm and Harrington: W. D.

Helix Sayii, Binney. Widely diffused, but scarce: Island of Orleans, near Quebec: W. C., and J. F. W. Montreal Mountain: near Brome lake: R J. F. Restigouche river, about five miles above the mouth of the Matapedia: R. B. Near Doran's lake, Grenville: W. D.

Helix hortensis, Muller. Brandy Pots and Hare Island: extending from Metis to Gaspé bay. R. B.

Helix tridentata, Say. Montreal Mountain, but very rare.

Helix monodon, Racket. Abundant throughout the district, in suitable situations. In Lower Canada the typical form is abundant but the varieties (?) H. fraterna, Say; and H. Leaii, Ward; have not occurred to me in Lower Canada .

Helix multidentata, Binney. In 1861 I found one living specimen of this species on the Island of Orleans, and not noticing the teeth, took it for H. capsella of Gould. I am indebted to Mr. Bland for the correction of this error.

Helix lineata, Say. A species widely distributed throughout the district, but not abundant.

Helix labyrinthica, Say. The same remarks will apply to this species as to the above. Island of Orleans, Montmorenci falls, etc.

Helix alternata, Say. Very abundant everywhere in Lower Canada.

Helix striatella, Anthony. In different situations to the above, but equally common.

Helix rufescens, Muller. Living in abundance at Quebec on that part of the Plains of Abraham known as the Cove fields. J. F. W.

Helix (*Zonites*) *cellaria*, Muller. Dead shells of this species have been taken by Mr. Fowler near gardens in Craig Street, Montreal.

Helix pulchella, Mull. Abundant throughout the province.

Helix concava, Say. Not very common, but apparently with a wide range.

Helix electrina, Gould. Near Brome Lake in the Eastern Townships: R. J. F.

Helix arborea, Say. One of the commonest of the Canadian land-snails.

Helix indentata, Say. Montreal Mountain R. J. F.

Helix asterisca, Morse. Valley of the Marsouin river; R. B.

Helix chersina, Say. (= H. fulva? Mull.) Common in damp situations.

Bulimus lubricus, Mull. Rivière du Loup; Trois Pistoles: Metis lakes, and along the Restigouche: R. B. Montreal Mountain: R. J. F., and J. F. W.

Bulimus harpa, Say. Montreal Mountain: R. J. F., and J. F. W. Rivière du Loup: J. F. W. Metis: mouth of Magdalen river, and very abundant in the Marsouin valley: R. B.

Bulimus marginatus, Say. (Pupa fallax, Say.) Sugar Bush Lake, and near Gate Lake: W. D.

Pupa armifera, Say. Plains of Abraham, Quebec: W. C. and J. F. W.

Pupa contracta, Say. Island of Orleans: J. F. W.

Vertigo simplex, Gould. Rivière du Loup : J. F. W. Valley of the Marsouin : along the Restigouche and at Metis : R. B.

Vertigo Gouldii, Binney. Island of Orleans, and Rivière du Loup : J. F. W. Sixteen-Island lake. W. D. Montreal Mountain : R. J. F.

Vertigo ovata? Say. Montreal mountain : R. J. F., and J. F. W. The only specimen taken was not quite adult, but appeared to belong to this species.

Carychium exiguum, Say. Sixteen-Island lake, one specimen : W. D.

DESCRIPTIONS OF NEW, OR IMPERFECTLY KNOWN SPECIES.

SPHŒRIUM.

(SECTION A. SPECIES WITH ROUNDED BUT NOT PROTUBERANT BEAKS.)

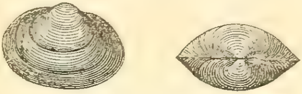

Figure 1.

Sphœrium sulcatum, Lamarck.

Animal white ; tubes, a light orange color.

Shell transversally oval, nearly equilateral, light in texture for its size ; posterior margin somewhat more pointed : anterior rounded ; base slightly curved ; valves convex ; beaks full raised above the outline of the shell ; posterior portion a little longer ; sulcations coarse, regular ; epidermis dark chestnut brown ; interior light blue ; hinge margin narrow, nearly a straight line ; cardinal teeth small, indistinct, situated somewhat towards the anterior side, double in both valves, and so placed as to assume the shape of the letter V reversed ; lateral teeth on a line with the primary teeth, large, strong and prominent.

Long. 11–16 ; lat. 71–61 ; diam. 5-16 inches.

The young is more equilateral than the adult, and more compressed ; it presents the shape of a quadrilateral, and is of a light lemon colour : the striations are as heavy as those of the mature shell. The hinge-margin is generally straight, but,in specimens from Alabama, Pennsylvania. and Rhode Island it is slightly curved.

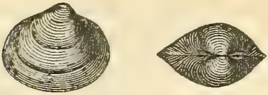

Figure 2.

Sphærium solidulum, Prime.

Animal not observed.

Shell transversely inequilateral, elongated, slightly convex; beaks full, not very prominent; anterior margin rounded; posterior drawn out to an angle; base slightly curved: epidermis variable, dark chestnut or brownish yellow, with sometimes a yellow zone on the basal margin; sulcations coarse, irregular; interior dark blue; hinge margin considerably curved; cardinal teeth double, in the shape of the letter V reversed; lateral teeth large; the anterior placed at an angle with the margin; the posterior more on a continuation of the curve.

Long. 9–16; lat. 7–16; diam. 5–16 inches.

Differs from the preceding species in being less elongated, more inequilateral, less convex; the hinge margin is more curved, and the shell is more solid than in the S. sulcatum. Having unfortunately mislaid my only specimen from L'Orignal, the figure is taken from a fine large specimen from the Little Miami river, at Waynesville, Ohio. Canadian specimens will probably be smaller, and with their distinctive characters less strongly marked.

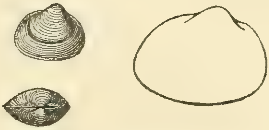

Figure 3.

Sphærium striatinum, Lamarck.

Animal white; tubes light reddish yellow.

Shell slight, transversely elongated, somewhat compressed, inequilateral; anterior margin rounded, posterior distended, inferior rounded; beaks full, not much raised; sulcations irregular, at times so light as hardly to be seen with the naked eye, thus giving the shell a lustrous appearance; colour varying from a light greenish-yellow to a darker shade; valves slight; interior blue; hinge margin slightly curved: cardinal teeth double, very small, of the same size; lateral teeth larger, not very prominent.

Long. 7–16; lat. 5-16; diameter 4–46 inches.

Compared to the Sphœrium solidulum, this species is smaller, more inequilateral, less tumid, more compressed, less solid, less heavily sulcated, and its posterior extremity is more distended.

A very common species in the rivers of Lower Canada; but appears to have been generally overlooked.

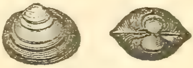

Figure 4.

Sphœrium rhomboideum, Say. (sp.)

Animal; white? syphons reddish-yellow.

Shell sub-globular, rhombic, orbicular, equilateral; anterior margin truncated; posterior slightly angular; basal nearly straight; beaks full, but not prominent; valves slight, convex towards the beaks, gradually decreasing in fullness towards the margins; interior blue; sulcations very delicate; epidermis olive-green, often with a straw coloured zone on the margins; young shell more compressed than the adult; hinge margin nearly straight; cardinal teeth rudimentary; lateral teeth distinct, somewhat acute, not elongated.

Long. 8–16; lat. 6–16; diam. 5–16 inches.

A very local, but gregarious species.

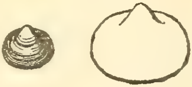

Figure 5.

Sphœrium occidentale, Prime.

Animal not observed.

Shell oval, small, pellucid, fragile, equilateral, margins rounded; valves slight, rather convex; beaks full, rounded, not much raised; sulcations very fine, hardly visible; epidermis horn coloured; cardinal teeth very diminutive, lateral teeth more distinct.

Long. 5-16; lat. 4-16; diam. 3-16 inches.

This species is remarkable for its completely oval shape, which renders it quite distinct from all others. Apparently rather rare in Lower Canada.

(Section B.—Species with Protuberant, or Calyculate Beaks.)

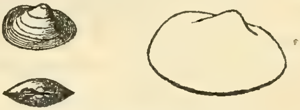

Figure 6.

Sphærium transversum, Say. sp.

Animal white, syphonal tubes pink, foot white.

Shell transversely oblong, elongated, sub-inequilateral, translucent; anterior side narrow; anterior margin rounded, posterior margin sub-truncate, basal very much curved; beaks placed somewhat on the anterior side, large, calyculate, very much raised above the outline of the shell; striæ very delicate; epidermis greenish-yellow (generally whitish in Canadian specimens), of a darker shade at times in the region of the beaks; valves slight; interior bluish; hinge-margin very nearly straight, narrow; cardinal teeth compressed, in the shape of the letter V reversed, and very much expanded; lateral teeth slightly elongated.

Long. 10-16; lat. 7-16; diam. 4-16 inches.

This large and delicate species is remarkable for its very transverse shape and for the narrowness of the anterior extremity as compared to the posterior.

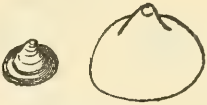

Figure 7.

Sphærium securis, Prime.

Animal pinkish; syphons of the same colour.

Shell rhombic-orbicular, ventricose, sub-equilateral, both sides nearly of the same length; anterior margin a little curved; posterior margin abrupt, forming an obtuse angle with the hinge margin; basal margin much longer than the superior margin, rounded;

beaks large, calyculate, slightly inclined towards the anterior, very approximate at apex: valves slight, very convex, especially in the region of the umbones; striæ delicate, regular, hardly perceptible; epidermis glossy in some cases, very variable in colour, but generally of a greenish-horn tint; at times of a brilliant yellow or straw colour (in Canadian specimens often translucent glossy white): hinge-margin curved, narrow; cardinal teeth very small, united at base; lateral teeth slight elongated; very narrow.

Long. 6-16; lat. 5-16; diam. 4-16. inches.

Unlike any other Canadian species.

The descriptions of the Lower Canadian species of Sphœrium have been taken from Mr. Prime's able monograph. The ensuing descriptions are original, except in the case of Limnæa ampla.

PISIDIUM.

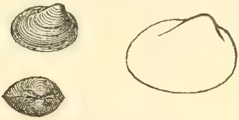

Figure 8.

Pisidium Virginicum, Brongniart.

Shell ovate, elliptical, oblique; strongly concentrically sulcate; "beaks placed much nearer one end;" slightly elevated, rounded, with a decided inclination to the anterior portion of the shell Posterior end elongated, rounded; anterior portion truncate; ventral margin convex. Easily distinguished from all the Lower Canadian Pisidia by its large size, strong concentric sulcations, and general outline.

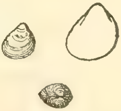

Figure 9.

Pisidium altile, Anthony.

Shell sub-triangular, very tumid (except in the variety *compressum*, which may prove a distinct species), especially in the region of the beaks: generally much broader from the umbo to the ventral margin, than in the opposite direction: beaks elongated into an obtuse point: anterior portion shortly rounded, but not truncate; posterior end forming a rounded, slightly pointed angle with the very convex ventral margin. Surface very finely striated.

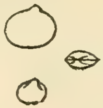

Figure 10.

Pisidium abditum, Haldeman.

Shell ovate, orbicular, not very inequilateral; ventricose; beaks prominent, rounded: general outline very variable, sometimes very oblique; in others the umbones almost central, the general form being nearly circular, but elongated and very bluntly pointed posteriorly: surface striated, the striæ stronger than in the preceding species.

LIMNÆIDÆ.

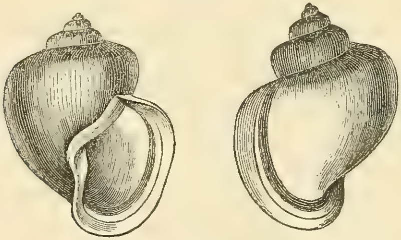

Figure 11.

Limnœa ampla, Mighels.

"L. testa amplâ, subovata; anfractibus quinque, convexis, superné geniculatis; suturâ valde impressâ; spira brevi; apertura latâ; umbilico profundo (?); columella valde plicata."

I have copied the original diagnosis of this very characteristic species from the proceedings of the Boston Society of Natural History for June 21st, 1843.

Dr. Mighel's description agrees with our Lower Canadian specimens in nearly every respect; but the Brome Lake specimens are imperforate, or very nearly so. The species is easily known by its large and wide body-whorl, which is decidedly angulated towards the sutures. The spire varies in length, but is seldom more than half as high as the last volution.

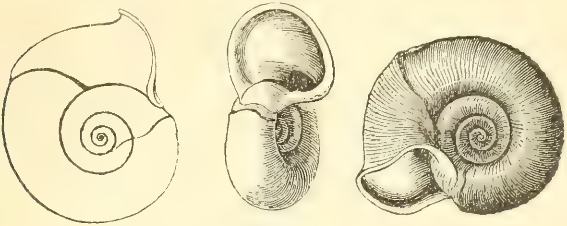

Figure 12.

Planorbis macrostomus, nobis.

Shell in many points closely resembling Planorbis lentus, Say : of which it may perhaps be only a variety. It is much larger, higher, and has deeper costæ ; its lines of growth are very prominently marked : the upper angle of the whorls as shown in the mouth, is more prominent. Lip *widely expanded*, and *reflected*, covered with a white enamel. In this latter character it differs from all the North American species of Planorbis. It is a species nearly allied to Planorbis lentus and P. trivolvis ; but apparently distinct from both.

Art. X.—*On the Antiquity of Man ; a Review of 'Lyell' and 'Wilson.'* *

Questions of human origins have always been popular, and have been agitated in all sorts of forms. Next to the dread question of the unknown future, the long buried past is one of the most attractive subjects of inquiry ; and while the faith of the Christian rests for both on the statements of Holy Scripture, the imagination of the poetical or the superstitious, and the reason of the philosopher or the sceptic have found ample scope for exercise. In our day, geological investigation on the one hand, and antiquarian and philological research on the other, have given an exact and scientific character to such researches, which, without detracting from their interest, has fitted them to attract a more sustained and systematic attention; hence the appearance of such works as those above named. One of these works is the summing up of the geological evidence in relation to the origin of man, by one of our greatest masters of inductive reasoning. The other is the effort of a skilful antiquarian and ethnologist to apply to the explanation of the primitive conditions of the old world, the facts derived from the study of the more recent primitive state of the western hemisphere. Both books are very valuable. Their methods are quite different, and their results as well; and it may be truly said that the geologist might have profited by the labours of the western antiquarian, had he known of them in time; and that the antiquarian might have found some new problems to solve, and difficulties to remove, had he read the work of the geologist. For this, among other reasons, it may be well to consider them together. It will be necessary for us in doing this to summarize the numerous and varied facts adduced, and the reasonings therefrom, and we shall follow the order employed by Sir C. Lyell, bringing in Dr. Wilson's antiquarian lore to our aid as we proceed.

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* "The Geological Evidences ot the Antiquity of Man with remarks on theories of the origin of species by variation," by Sir Charles Lyell, F.R.S., 8vo. pp. 520, illustrated. London, John Murray. Montreal, Dawson, Bros.

"Pre-historic Man.—Researches into the origin of Civilization in the Old and New World," by Daniel Wilson, LL.D., Prof. of History in University College, Toronto, 2 vols. 8vo. pp. 488-499, illustrated. London, MacMillan & Co. Montreal, Dawson, Bros.

The great question to be noticed in this review is that of the connection of human with geological history. How far back in that almost boundless antiquity disclosed by the geologist has man extended? At what precise point of the geological scale was he introduced on the mundane stage, and what his surroundings and condition in his earlier stages? In answer to these questions, negative geological evidence, and some positive considerations testify, without a dissenting voice, that man is very modern. All the evidences of his existence have until the last few years belonged exclusively to the Recent or latest period of the geological chronology. Certain late observations would, however, indicate that man may have existed in the latter part of the Post-pliocene period, and may have been contemporary with some animals now extinct. Still the evidences of this, as well as its true signifiance, are involved in much doubt; partly because many of the facts relied on are open to objection, partly because of the constant accession of new items of information, and partly because the age of the animals, whose remains are found with those of man, and the time required by the physical changes involved, are not certain.

To these questions Sir Charles addresses himself, with all his vast knowledge of facts relating to tertiary geology, and his great power of generalisation; and he has, for the first time, enabled those not in the centre of the discussions which have for a few years been carried on upon this subject, to form a definite judgment on the geological evidence of the antiquity of our species.

As a necessary preliminary, Sir Charles inquires as to the *recent* remains of man, including those which are pre-historic in the sense of antedating secular history, but which do not go back to the period of the extinct mammalia. He refers in the first place to the detailed researches of the Danish antiquaries, respecting certain remains in heaps of oyster-shells, found on the Danish coast, (which appear to be precisely similar to those heaps accumulated by the American Indians on our coasts from Prince Edward Island to Georgia); and respecting similar remains found in peat bogs in that country. These remains show three distinct stages of unrecorded human history in Denmark:—1st. A *stone period*, when the inhabitants were small sized men, brachykephalous or short headed men, like the modern Lapps, using stone implements, and subsisting by hunting. Then the country, or a considerable part of it was covered by forests of Scotch fir (*Pinus Sylvestris*). 2nd. A *bronze period*, in which implements of bronze as well as of stone were used, and the skulls of the people were larger and longer than in the previous period; while the country seems to have been covered with forests of oak (*Quercus robur*). 3rd. An *iron period*, which lasted to the historic times, and in which beech forests replaced those of oak. All of these remains are geologically recent; and except the changes in the forests, and of some indigenous animals in consequence, and probably a slight elevation of some parts of Denmark, no material changes in organic or inorganic nature have occurred.

The Danish antiquaries have attempted to calculate the age of the oldest of these deposits, by considerations based on the growth of peat, and the succession of trees; but these calculations are obviously unreliable. The first forest of pines would, when it attained maturity, naturally be destroyed, as usually happens in America, by forest conflagrations. It might perish in this way in a single summer. The second growth which succeeded, would in America be birch, poplar, and similar trees, which would form a new and tall forest in half a century; and in two or three centuries would probably be succeeded by a second permanent forest, which in the present case seems to have been of oak.* This would be of longer continuance, and would, independently of human agency, only be replaced by beech, if, in the course of ages, the latter tree proved itself more suitable to the soil, climate, and other conditions. Both oak and beech are of slow extension, their seeds not being carried by the winds, and only to a limited degree by birds. On the other hand the rechanges of forests cannot have been absolute or universal. There must have been oak and beech groves even in the pine woods ; and the growing and increasing beech woods would be contemporary with the older and decaying oak forest, as this last would probably perish not by fire, but by decay, and by the competition of the beeches. In like manner the growth of peat is very variable even in the same locality. It goes on very rapidly when moisture and other conditions are favourable, and especially when it is aided by wind-falls, drift-wood, or beaver-dams, impeding drainage and contributing to the accumulation of vegetable matter. It is retarded and finally terminated by the rise of the surface above the drainage level, by the clearing of the country, or by the establishment of natural or artificial drainage. On the one hand all the changes observed in Denmark may have taken place within a minimum time of two thousand years. On the other hand no one can affirm that either of the three successive forests may not have flourished for that length of time. A chronology measured by years, and based on such data, is evidently worthless.

Possibly a more accurate measurement of time might be deduced from the introduction of bronze and iron. If the former was, as many antiquarians suppose, a local discovery, and not introduced from abroad, it can give no measurement of time whatever ; since, as the facts so clearly detailed by Dr. Wilson show, while a bronze age existed in Peru, it was the copper age in the Mississippi valley, and the stone age elsewhere ; these conditions might have co-existed for any length of time, and could give no indication of relative dates. On the other hand the iron introduced by European commerce spread at once over the continent, and came into use in the most remote tribes, and its introduction into America clearly marks an historical epoch.

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* The details of this process, as it occurs in America, will be found noticed in a paper by the writer in the Edin. Phil. Journal for 1847. Such changes are constantly in progress in the American forests.

With regard to bronze in Europe, we must bear in mind that tin was to be procured only in England and Spain, and in the latter in very small quantity : the mines of Saxony do not seem to have been known till the middle ages. We must further consider that tin ore is a substance not metallic in appearance, and little likely to attract the attention of savages; and that, as we gather from a hint of Pliny, it was probably first observed, in the west at least, as stream tin, in the Spanish gold washings. Lastly, when we place in connection with these considerations, the fact that in the earliest times of which we have certain knowledge, the tin trade of Spain and England was monopolized by the Phœnicians, there seems to be a strong probability that the extension of the trade of this nation to the western Mediteranean,really inaugurated the bronze period. The only valid argument against this, is the fact that moulds and other indications of native bronze casting have been found in Switzerland, Denmark, and elsewhere ; but these show nothing more than that the natives could re-cast bronze articles, just as the American Indians can forge fish-hooks and knives out of nails and iron hoops. Other considerations might be adduced in proof of this view, but the limits of our article will not permit us to refer to them. The important questions still remain : when was this trade commenced, and how rapidly did it extend itself from the sea-coast across Europe. The British tin trade must have been in existence in the time of Herodotus, though his notion of the locality was not more definite than that it was in the extremity of the earth. The Phœnician settlements in the western Mediterranean must have existed as early as the time of Solomon, when "Ships of Tarshish" was the general designation of sea-going ships for long voyages. How long previously these colonies existed we do not know ; but considering the great scarcity and value of tin in those very ancient times, we may infer that perhaps only the Spanish, and not the British deposits were known thus early ; or that the Phœnicians had only indirect access to the latter. Perhaps we may fix the time when these traders were able to supply the nations of Europe with abundance of bronze in exchange for their products, at, say 1000 to 1200 B.C., as the earliest probable period ; and probably from one to two centuries would be a sufficient allowance for the complete penetration of the trade throughout Europe ; but of course wars or migrations might retard or accelerate the process ; and there may have been isolated spots in which a partial stone period extended up to those comparatively modern times, when first the Greek trade, and afterward the entire overthrow of the Carthaginian power by the Romans, terminated forever the age of bronze, and substituted the age of iron. This would leave, according to our ordinary chronologies, at least ten or fifteen centuries for the post-diluvian stone period; a time quite sufficient, in our view, for all that part of it represented by such remains as those of the Danish coast, and the still more remarkable platform habitations, whose remains have been found in the Swiss lakes, and which belong properly to the *recent* period of geology. In connection with this we would advise the reader to study the many converging lines of evidence derived from history, from monuments, and from language, which Dr. Wilson shows, in his concluding chapter, to point to the comparatively recent origin of at least post-diluvian man. Let it be observed, also, that the attempts of Bunsen and others to deduce an extraordinarily long chronology from Egyptian monuments, and from the diversity of languages, have signally failed; and that the observations made by Mr. Horner in the Nile alluvious are admitted to be open to too many doubts to be relied on.*

Before leaving the recent period, it is deserving of note that Sir C. Lyell shows on the best evidence, that in Scotland, since the building of the Wall of Antoninus, an elevation of from twenty-five to twenty-seven feet has occurred both on the eastern and western coast, and consequently that the raised sea bottoms containing canoes, &c., in the valley of the Clyde, supposed by some to be of extremely ancient date, were actually under water in the time of the Romans; a fact of which, but for their occupation of the country, we should have been ignorant.

From the Recent period we pass, under the guidance of Sir Charles, to the Post-pliocene, geologicaly distinguished from the Recent by the fact that its deposits contain the bones of many great extinct quadrupeds; as for instance the mammoth, *Elephas primigenius*, the wooly rhinoceros, *R. tichorhinus*, and others, heretofore, (but it would seem on insufficient evidence,) supposed to have disappeared before the advent of man. The evidence now adduced that primeval man was really contemporary with these creatures is manifold, and apparently conclusive, and in the work before us is carefully sifted and weighed in all its bearings, much being rejected as inapplicable or uncertain. The evidences relied on are chiefly the following:

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* The chronology deduced from the Delta of the Tinière, which would give to the stone period an antiquity of 5000 to 7000 years, appears to us to be similarly defective; and the data assigned to human remains in the valleys of the Mississippi and Ohio, and the old reefs of Florida still more so.

1. Human remains found with those of extinct animals in caves in Belgium, in England, and elsewhere, in circumstances which preclude the probability of their mixture by interments or other modern causes.

2. The finding of flint implements associated with bones of extinct animals in the valley of the Somme, and elsewhere.

3. A supposed sepulchral cave of this period discovered in the south of France. In addition to these there are many minor facts tending to the same conclusion, but with less distinctness.

It is impossible to give extracts which will convey any adequate idea of the facts adduced from the above sources, but the following paragraphs may serve as examples of some of them. They relate to evidence that man was contemporary with extinct animals, afforded by caverns near Liege, explored by Dr. Schmerling, and to the similar evidence obtained in the cave of Brixham in England.

" The rock in which the Liége caverns occur belongs generally to the Carboniferous or Mountain limestone, in some few cases only, to the older Devonian formation. Whenever the work of destruction has not gone too far, magnificent sections, sometimes 200 and 300 feet in height, are exposed to view. They confirm Schmerling's doctrine, that most of the materials, organic and inorganic, now filling the caverns, have been washed into them through narrow vertical or oblique fissures, the upper extremities of which are choked up with soil and gravel, and would scarcely ever be discoverable at the surface, especially in so wooded a country. Among the sections obtained by quarrying, one of the finest which I saw was in the beautiful valley of Fond du Forêt, above Chaudefontaine, not far from the village of Magnée; where one of the rents communicating with the surface has been filled up to the brim with rounded and half-rounded stones, angular pieces of limestone and shale, besides sand and mud, together with bones, chiefly of the cave-bear. Connected with this main duct, which is from one to two feet in width, are several minor ones, each from one to three inches wide, also extending to the upper country or table-land, and choked up with similar materials.

They are inclined at angles of 30° and 40°, their walls being generally coated with stalactite, pieces of which have here and there been broken off and mingled with the contents of the rents, thus helping to explain why we so often meet with detached pieces of that substance in the mud and breccia of the Belgian caves. It is not easy to conceive that a solid horizontal floor of hard stalagmite should, after its formation, be broken up by running water; but when the walls of steep and tortuous rents, serving as feeders to the principal fissures, and to inferior vaults and galleries, are encrusted with stalagmite, some of the incrustation may readily be torn up when heavy fragments of rock are hurried by a flood through passages inclined at angles of 30° or 40°.

" The decay and decomposition of the fossil bones seem to have been arrested in most of the caves by a constant supply of water charged with carbonate of lime, which dripped from the roofs while the caves were becoming gradually filled up. By similar agency the mud, sand, and pebbles were usually consolidated.

" The following explanation of this phenomenon has been suggested by the eminent chemist Liebig. On the surface of Franconia, where the limestone abounds in caverns, is a fertile soil in which vegetable matter is continually decaying. This mould or humus, being acted on by moisture and air, evolves carbonic acid, which is dissolved by rain. The rain-water, thus impregnated, permeates the porous limestone, dissolves a portion of it; and afterwards, when the excess of carbonic acid evaporates in the caverns, parts with the calcareous matter and forms stalactite. So long as water flows, even occasionally, through a suite of caverns no layer of pure stalagmite can be produced; hence the formation of such a layer, is generally an event posterior in date to the cessation of the old system of drainage; an event which might be brought about by an earthquake causing new fissures, or by the river wearing its way down to a lower level, and thenceforth running in a new channel.

" In all the subterranean cavities, more than forty in number, explored by Schmerling, he only observed one cave, namely that of Chokier, where there were two regular layers of stalagmite, divided by fossiliferous cave-mud. In this instance, we may suppose that the stream, after flowing for a long period at one level, cut its way down to an inferior suite of caverns, and, flowing through them for centuries, choked them up with debris; after which it rose once more to its original higher level: just as in the Mountain limestone district of Yorkshire some rivers, habitually absorbed by a "swallow hole," are occasionally unable to discharge all their water through it; in which case they rise and rush through a higher subterranean passage, which was at some former period in the regular line of drainage, as is often attested by the fluviatile gravel still contained in it.

"There are now in the basin of the Meuse, not far from Liége, several examples of engulfed brooks and rivers: some of them, like that of St. Hadelin, east of Chaudefontaine, which reappears after an underground course of a mile or two; others, like the Vesdre, which is lost near Goffontaine, and after a time re-emerges; some, again, like the torrent near Magnée, which, after entering a cave, never again comes to the day. In the season of floods such streams are turbid at their entrance, but clear as a mountain-spring where they issue again; so that they must be slowly filling up cavities in the interior with mud, sand, pebbles, snail-shells, and the bones of animals which may be carried away during floods.

"The manner in which some of the large thigh and shank bones of the rhinoceros and other pachyderms are rounded, while some of the smaller bones of the same creatures, and of the hyæna, bear, and horse, are reduced to pebbles, shows that they were often transported for some distance in the channels of torrents, before they found a resting-place.

"When we desire to reason or speculate on the probable antiquity of human bones found fossil in such situations as the caverns near Liége, there are two classes of evidence to which we may appeal for our guidance. First, considerations of the time required to allow of many species of carnivorous and herbivorous animals, which flourished in the cave period, becoming first scarce, and then so entirely extinct as we have seen that they had become before the era of the Danish peat and Swiss lake dwellings: secondly, the great number of centuries necessary for the conversion of the physical geography of the Liége district from its ancient to its present configuration; so many old underground channels, through which brooks and rivers flowed in the cave period, being now laid dry and choked up.

"The great alterations which have taken place in the shape of the valley of the Meuse and some of its tributaries, are often demonstrated by the abrupt manner in which the mouths of fossiliferous caverns open in the face of perpendicular precipices, 200 feet or more in height above the present streams. There appears also, in many cases, to be such a correspondence in the openings of caverns on opposite sides of some of the valleys, both large and small, as to incline one to suspect that they originally belonged to a series of tunnels and galleries, which were continuous before the present system of drainage came into play, or before the existing valleys were scooped out. Other signs of subsequent fluctuations are afforded by gravel containing elephants' bones at slight elevations above the Meuse and several of its tributaries. The loess also, in the suburbs and neighbourhood of Liége, occurring at various heights in patches lying at between 20 and 200 feet above the river, cannot be explained without supposing the filling up and re-excavation of the valleys at a period posterior to the washing in of the animal remains into most of the old caverns. It may be objected that according to the present rate of change, no lapse of ages would suffice to bring about such revolutions in physical geography as we are here contemplating. This may be true. It is more than probable that the rate of change was once far more active than it is now. Some of the nearest volcanoes, namely, those of the Lower Eifel about sixty miles to the eastward, seem to have been in eruption in post-pliocene times, and may perhaps have been connected and coeval with repeated risings or sinkings of the land in the basin of the Meuse. It might be said, with equal truth, that according to the present course of events, no series of ages would suffice to reproduce such an assemblage of cones and craters as those of the Eifel (near Andernach for example); and yet some of them may be of sufficiently modern date to belong to the era when man was contemporary with the mammoth and rhinoceros in the basin of the Meuse.

"But although we may be unable to estimate the minimum of time required for the changes in physical geography above alluded to, we cannot fail to perceive that the duration of the period must have been very protracted, and that other ages of comparative inaction may have followed, separating the post-pliocene from the historical periods, and constituting an interval no less indefinite in its duration."

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"As the osseous and other contents of Kent's Hole had, by repeated diggings, been thrown into much confusion, it was thought desirable in 1858, when the entrance of a new and intact bone-cave was discovered at Brixham, three or four miles west of Torquay, to have a thorough and systematic examination made of it. The Royal Society made two grants towards defraying the expenses,* and a committee of geologists was charged with the investigations, among whom Mr. Prestwich and Dr. Falconer took an active part, visiting Torquay while the excavations were in progress under the superintendence of Mr. Pengelly. The last-mentioned geologist had the kindness to conduct me through the subterranean galleries after they had been cleared out in 1859; and I saw, in company with Dr. Falconer, the numerous fossils which had been taken from the subterranean fissures and tunnels, all labelled and numbered, with references to a journal kept during the progress of the work, and in which the geological position of every specimen was recorded with scrupulous care.

"The discovery of the existence of this suite of caverns near the sea at Brixham was made accidentally, by the roof of one of them falling in. None of the five external openings now exposed to view in steep cliffs or the sloping side of a valley, were visible before the breccia and earthy matter which blocked them up were removed during the late exploration. According to a ground-plan drawn up by Professor Ramsay, it appears that some of the passages which run nearly north and south are fissures connected with the vertical dislocation of the rocks, while another set, running nearly east and west, are tunnels, which have the appearance of having been to a great extent hollowed out by the action of running water. The central or main entrance, leading to what is called the reindeer gallery, because a perfect antler of that animal was found sticking in the stalagmitic floor, is ninety-five feet above the level of the sea, being also about sixty above the bottom of the adjoining valley. The united length of the five galleries which were cleared out amounted to several hundred feet. Their width never exceeded eight feet. They were sometimes filled up to the roof with gravel, bones, and mud; but occasionally there was a considerable space between the roof and floor. The latter, in the case of the fissure-caves, was covered with stalagmite, but in the tunnels it was usually free from any such incrustation. The following was the general succession of the deposits forming the contents of the underground passages and channels:—

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* When these grants failed, Miss Burdett-Coutts, then residing at Torquay, liberally supplied the funds for completing the work.

"1st. At the top, a layer of stalagmite, varying in thickness from one to fifteen inches, which sometimes contained bones, such as the reindeer's horn, already mentioned, and an entire humerus of the cave-bear.

"2ndly. Next below, loam or bone-earth, of an ochreous-red colour, from one foot to fifteen feet in thickness.

"3rdly. At the bottom of all, gravel with many rounded pebbles in it, probed in some places to the depth of twenty feet without being pierced through, and as it was barren of fossils, left for the most part unremoved.

"The mammalia obtained from the bone-earth consisted of *Elephas primigenius*, or mammoth; *Rhinoceros tichorhinus; Ursus spelœus; Hyœna spelœa; Felis spelœa*, or the cave-lion; *Cervus tarandus*, or the reindeer; a species of horse, ox, and several rodents, and others not yet determined.

"No human bones were obtained anywhere during these excavations, but many flint knives, chiefly from the lowest part of the bone-earth; and one of the most perfect lay at the depth of thirteen feet from the surface, and was covered with bone-earth of that thickness. From a similar position was taken one of those siliceous nuclei, or cores, from which flint flakes had been struck off on every side. Neglecting the less perfect specimens, some of which were met with even in the lowest gravel, about fifteen knives, recognized by the most experienced antiquaries as artificially formed, were taken from the bone-earth, and usually from near the bottom. Such knives, considered apart from the associated mammalia, afford in themselves no safe criterion of antiquity, as they might belong to any part of the age of stone, similar tools being sometimes met with in tumuli posterior in date to the era of the introduction of bronze. But the anteriority of those at Brixham to the extinct animals is demonstrated not only by the occurrence at one point in overlying stalagmite, of the bone of a cave-bear, but also by the discovery at the same level in the bone-earth, and in close proximity to a very perfect flint tool, of the entire left hind-leg of a cave-bear. This specimen, which was shown me by Dr. Falconer and Mr. Pengelly, was exhumed from the earthy deposit in the reinder gallery, near its junction with the flint-knife gallery, at the distance of about sixty-five feet from the main entrance. The mass of earth containing it was removed entire, and the matrix cleared away carefully by Dr. Falconer, in the presence of Mr. Pengelly. Every bone was in its natural place, the femur, tibia, fibula, ankle-bone, or astragalus, all in juxta position. Even the patella or detached bone of the kneepan was searched for, and not in vain. Here, therefore, we have evidence of an entire limb not having been washed in a fossil state out of an older alluvium, and then swept afterwards into a cave, so as to be mingled with flint implements, but having been introduced when clothed with its flesh, or at least when it had the separate bones bound together by their natural ligaments, and in that state buried in mud.

"If they were not all of contemporary date, it is clear from this case, and from the humerus of the *Ursus spelæus*, before cited as found in a floor of stalagmite, that the bear lived after the flint tools were manufactured, or in other words, that man in this district preceded the cave-bear."

Multitudes of questions arise out of these observations, and many of them will probably long remain unanswered; but we may in the remainder of this article, profitably restrict ourselves to three of them :

1. What style of men were these contemporaries of the mammoth, as compared with those who now walk the earth ?

2. How great is their antiquity ?

3. What bearing have the conclusions which we must form on these points, on the facts known to us on other evidence than that of geology, as to the origin and early history of man ?

The writer of these pages, on a former occasion, ventured to predict that if any osseous remains of antediluvian man should be discovered, they would probably present characters so different from those of modern races that they might be regarded as belonging to a distinct species.* With perhaps one exception, this anticipation has not yet been realized. The skull from the cave of Engis, in Belgium, supposed to be the oldest known, is in the judgment of Prof. Huxley, not by any means abnormal, but on the contrary, not unlike some European skulls. Another skull, that of Neanderthal, not found with remains of extinct animals, and therefore of uncertain geological antiquity, has however excited more attention than the Engis skull. Its pre-historic antiquity has been assumed by many writers, and its low forehead, prominent superciliary ridges, and general flatness, giving a more ape-like air than those of the heads of any modern tribes, together with the great stoutness and strong muscular impressions of the bones found with it, have been regarded as confirmatory evidence of this supposition. It is quite certain however that the characters for which this skeleton is eminent, are found, though perhaps in a less degree, in the rude tribes of America and Australia. It is also doubtful whether this skeleton really indicates a race at all. It may have belonged to one of those wild men, half crazed, half idiotic, cruel and strong, who are always more or less to be found living on the outskirts of barbarous tribes, and who now and then appear in civilized communities, to be consigned perhaps to the penitentiary or to the gallows, when their murderous propensities manifest themselves. Still, as we shall show under our third head, this Neanderthal man is nearer in some respects to our historical idea of antediluvian man than any other of these very ancient examples; though, as Lyell properly suggests, there is no absolutely valid reason for assuming that he may not even have belonged to the same nation with the Engis man; since nearly as great differences are found in the skulls of individual members of some unmixed savage races.

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* Archaia p. 237.

One remarkable conclusion however deducible from the answer to this our first question, must not be omitted. Of all the criteria for the distinction of races of men, the skull is probably the most certain, and as any one may perceive, who reads Dr. Wilson's book, it affords in really reliable hands, the best possible evidence of distinctness or of unity, except where great mixtures have occurred. Now man is one of the most variable animals; and yet it would seem that, since the post-pliocene period, he has changed so little that the skulls of these post-pliocene men fall within the limits of modern varieties; and this, while so great changes have occurred that multitudes of mammals once his contemporaries have utterly perished. Now if these men are so ancient as many geologists would assume, nay if they are even 6000 years old, surely the human race is very permanent, and Prof. Huxley may well say that "the comparatively large cranial capacity of the Neanderthal skull, overlaid though it may be with pithecoid bony walls, and the completely human proportions of the accompanying limb-bones, together with the very fair development of the Engis skull, clearly indicate that the first traces of the primordial stock whence man proceeded, need no longer be sought by those who entertain any form of the doctrine of development, in the newest tertiaries; but that they may be looked for in an epoch more distant from the age of the *Elephas primigenius* than that is from us." They may, in short, spare themselves the trouble of looking for any such transition from apes to men in any period; for this great lapse of time renders the species practically permanent; more especially when we bear in mind that of the numerous species whose remains are found with those of these ancient men, some have continued unchanged up to our time, and the rest have become extinct, while not one can be proved to have been transmuted into another species.

Sir Charles devotes no less than five concluding chapters to this doctrine of transmutation, as held by Darwin and others. He does not commit himself to it, but wishes to give it due consideration, as a possible hypothesis, which may at least lead to great truths. We are not disposed to give it quite so high a position. Mr. Darwin's book impressed us with the conviction that his hypothesis really explains nothing not otherwise explicable, and requires many assumptions difficult of belief; while the whole argument in its favour is essentially of the nature of reasoning in a circle. The point to be proved is, that variations arising from external influences and "natural selection" may produce specific diversity. Now in order to begin our proof of this, we require at least one species, with all its powers and properties, to commence with. This being granted, we proceed to show that it may vary into several races, and that these races, if isolated, may be kept distinct and perpetuated. We further proceed to show that these races differ so much, that if wild, and not tampered with, we might suppose them originally distinct. So far all goes well with our demonstration; but we find that many of the differences of these races are of the nature of mere monstrosities, like the six fingers of some men, which, as far as they go, would exclude the individuals having them, not only from their species, but from their order or class. Further, we find that the differences which do resemble those of species, have not, when tried by the severe test of crossing, that fixity which appertains to true specific differences; so that with due care all our races can be proved to belong to but one species. Thus our whole argument falls to the ground; unless we are content quietly to assume the thing to be proved, and to say, that after showing that some species are very variable, we have established a certain probability that they may overpass the specific limits; though the fact that with all this variability, no species has been known practically to overpass these limits;

should logically bring us to the opposite conclusion; viz., that the laborious investigations of Mr. Darwin have more than ever established the fixity of species, though they have shown reason to believe that many so-called species are mere varieties.

Applying this to man, and even admitting, what Sir Charles Lyell very properly declines to admit, that the differences between men and apes are in all respects, only differences of degree, and further admitting with Prof. Huxley, that the difference between the size of the brain in the highest and lowest races of men is greater than the differences between the latter and the highest apes, nothing would be proved towards the doctrine of transmutation; for all these variations might occur without the ape ever overleaping the dividing line between it and the man; and the one fact to be proved is that this overleap is possible.

Perhaps this question as to man and apes, which some recent transmutationists have started, is one of the most damaging aspects of the doctrine, since it show sbetter than other cases the essential absurdity of supposing the higher nature to be evolved out of the lower; and thus startles the common sense of ordinary readers, who might detect little that is unreasonable in the transmutation of an oyster into a cockle, or even of a pigeon into a partridge; more especially if the reader or auditor is enabled to perceive the resemblance of type between these creatures, without receiving the further culture necessary to appreciate specific and generic difference, and thus is made ready to believe that similarity of type means something more than similar plan of construction. It is very curious too to observe ,that while these theorists seize on occasional instances of degraded individuals in man as evidence of *atavism* reverting to a simian ancestry, they are blind to the similar explanation which those who hold an opposite view may give to the cases of superior minds appearing in low races, in which the transmutationists can see nothing but spontaneous elevation. It is also deserving of a passing remark that while, as Dr. Gray shows, the doctrine of transmutation is not subversive of all natural theology, that is, so long as transmutationists admit the presiding agency of a spiritual Supreme Being, the application of such views to the human species, attacks leading doctrines of that biblical Christianity which is practically of so much higher importance to man than mere natural theology.

Still some of our modern naturalists follow with as much pertinacity these transmutation hypotheses, as did the old alchemists their attempts to transmute chemical species into each other. Perhaps the comparison is hardly fair to the older school of speculators, for chemical species or elements tend by their combination to form new substances, which animal and vegetable species do not; and by so much the balance of antecedent probability was on the side of the alchemists, as compared with the transmutationists, though their methods and doctrines were very similar. We may, however, at least hope that, like the researches of the alchemists, those of their successors may develop new and important truths. Leaving then this much vexed topic, let us proceed to our second inquiry, as to the actual antiquity of these primitive men.

This antiquity is of course to be measured by the geological scale of time, whose periods are marked not by years or centuries, but by the extinction of successive faunas and floras, and the progress of physical changes. With respect to the first of these marks of time, we confess that we have not regarded the observations of Boucher de Perthes and others, as free from the suspicion that accidental mixtures of human and fossil bones, or other causes not taken into the account, may have vitiated their conclusions; and this suspicion still applies to some of the cases cited by Sir C. Lyell, as more or less certain proofs. After reading the statements of the present volume, we think the Belgian and Brixham caves may be taken as good evidence of the probable contemporaneousness of man with the *Elephas primigenius*, *Rhinoceros tichorhinus*, *Ursus spelœus*, and their contemporaries; or rather as evidence that man was beginning to appear in Western Europe before those animals had finally disappeared. In consequence of some flaws in the evidence, as it appears to a reader at a distance, we cannot as yet so implicitly receive the evidence of the Somme flint weapons. The cave of Aurignac described by M. Lartet, and in which seventeen human skeletons were found buried, apparently in a sitting posture, cannot be relied on, owing to the late period at which it was explored. We are sorry to doubt this unique instance of antediluvian sepulchral rites, but all the appearances *actually seen** by M. Lartet are better explicable on the supposition that a cave, once tenanted by the cave bear and hyæna, had been partially emptied of its contents by some primitive tribe, who had broken up the bones of the extinct animals, not for their marrow, but to make tools and ornaments of them, and had subsequently used the cave as a place of burial, and the ground in front of it for "feasts for the dead." If the bones are still so perfect as M. Lartet asserts, they must have been quite sound when first disturbed at the early historical time in which the cave may have been ransacked. Further, the skeleton of *Ursus spelœus* found in the interior, was below the place of deposit of the human skeletons; and we can suppose it to have been contemporaneous, only by the unlikely theory that the earth containing this skeleton was placed in the cave by the aboriginal people.*

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* We refer to Mr. Lartet's account of his discovery in the Natural History Review, as well as the more concise statement given in the book before us.

We give the above leading cases as examples of the rest which are cited, and all of which may in like manner be divided into those which afford probable, though not absolutely certain evidence of post-pliocene man, and those which are liable to too grave suspicion to be accepted as evidence. It may be said that we should be more ready to believe, and less critical, but it is not the wont of geologists to be so, when new facts and conclusions are promulgated; and the present case involves too important consequences, both in relation to history, and to the credibility of geological proof in general, to escape the most searching criticism. Geologists must beware lest their science, at the point where it comes into contact with other lines of investigation, and where its own peculiar methods are most liable to err, should be found wanting, and its reliability fall into discredit.

But when did the fossil mammals named above, really become extinct. As a preliminary to our answer to this question, we may state that in Western Europe, in the post-pliocene period of geologists, these animals were contemporary with many still extant, some of them in Europe, others elsewhere. Pictet even maintains that all, or nearly all of our modern European mammals co-existed with these animals in the post-pliocene period, and that consequently there has since that time been a progressive diminution of species down to the present day. The mammoth, *Elephas primigenius*, existed, or perhaps began to exist at a still more ancient period,—the newer pliocene; when it was contemporary with *Elephas meridionalis* and other animals of an older fauna. It continued to survive until the introduction of the modern mammals, and then became extinct along with *Rhinoceros tichorhinus* and several other species, which, however, may have been of younger date than itself. With these species lived the *Megaceros Hibernicus*, or great Irish stag, which lasted longer, but perished before the dawn of history. With them also lived the *Bos primigenius*, or gigantic wild ox, the aurochs, the musk-ox, and the rein-deer. The first of these existed wild until the time of Cæsar; the second is still preserved in a forest in Lithuania; the third exists now in Arctic America, and the fourth still remains in Lapland. With them also co-existed the wolf, the fox, the hare, the stag, and other creatures still living in western Europe.

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* It is certainly very curious that the objects and arrangements of these caves and other ancient European depositories, are so thoroughly American, even to the round stone hammers, whose use is so oddly misinterpreted by the Danish antiquaries.

That these creatures have been disappearing at different times seems certain; some may have been exterminated by man, but the greater part must have perished from other causes. They may have gone *seriatim*, or in considerable numbers at or near the same time; and there seems some reason to believe in a considerable and rapid decadence at the end of the post-pliocene and beginning of the recent period. One cause which may be assigned is change of climate. The climate of Europe in the time of the mammoth was very cold, as indicated by the evidence of glaciers, and other forms of ice action, and by the presence of the musk ox. No doubt the extinction of this creature, and of the mammoth and tichorhine rhinoceros as well, would follow from the amelioration in this respect as the recent period approached. This change of climate depended on geographical changes, modifying the distribution of land and water, and the direction of ocean currents. A subsidence in central America or in Florida, might restore the climate of the mammoth by altering the course of the gulf stream; and an elevation of land in these regions may have introduced the climate of the recent period. There is abundant evidence that much subsidence and elevation did occur while these changes in organic life were in progress; and these may, more directly, by the submergence or elevation of large areas in Europe itself, have tended to extinguish species, or introduce them from other regions. All these points being granted, and abundant evidence of them will be found given by Sir C. Lyell, it remains to ask, can we convert the period required for these changes into solar years? There is but one way of doing this in consistency with the principles of modern geology, and this is to ascertain how long a time would be occupied by agencies now in operation in effecting the changes of elevation, subsidence, erosion and deposit, observed. Reasoning on this principle, it is plain that a vast lapse of time will be required, and that we may place the earliest men and the latest mammoths at an almost incredible distance before the oldest historical monuments of the human race.

But can we assume any given rate for such changes? Not certainly till all the causes which may have influenced them can be ascertained and weighed. We have only recently learned that Scotland has risen twenty-five feet in 1700 years; but we do not know that this elevation has been uniform and continuous. There is another older sea-level at forty-four feet above the present coast; and there is a still higher sea-level 524 feet above the sea, which certainly goes back to the time of the mammoth. Now we may calculate that if an elevation of twenty-five feet requires 1700 years, an elevation of 500 feet will require twenty times that length of time; but if we should find on further investigation that ten of the twenty-five feet were raised in the first century of the seventeen, and that the rate had gradually decreased, our calculation must be quite different, and even then might be altogether incorrect, since there may have been periods of rest or of subsidence; so that "such estimates must be considered in the present state of science as tentative and conjectural."

Again, at the rate in which the Somme, the St. Lawrence and the Mississippi now cut their channels and deposit alluvium, we can calculate that several tens of thousands of years must have elapsed since the mammoth roamed on their banks; and we have been accustomed to rest on these calculations as close approximations to the truth: but Sir Charles Lyell has, in his present work, introduced a new and disturbing element, in the strong probability which he establishes that the cold of the glacial period extended to a later time than we have hitherto supposed. If, when the gravels of the Somme were deposited, the climate was of a sub-arctic character, we have to add to modern erading causes the influence of frost, greater volume of water, spring freshets, and ice-jams, and the whole calculation of time must be revised. So, if it can be proved that when the St. Lawrence began to cut the ravine of Niagara, in the post-pliocene or newer pliocene period, there were great glaciers in the basin of Lake Superior, all our calculations of time would be completely set at nought.

Such are the difficulties which beset the attempt to turn the monumental chronology of geology into years of solar time. The monuments are of undeniable authenticity, and their teachings are most valuable, but they are inscribed with no record of human years, and we think geologists may wisely leave this matter where the Duke of Argyle, in his address to the Royal Society, lately placed it, as a doubtful point, in so far as geological evidence is concerned, whether the mammoth lived later than we have hitherto supposed, or man lived earlier. Still, as we have already stated, those geologists who hold that we must reason inflexibly on rates of change indicated by modern causes, will necessarily, on the evidence as it now stands, maintain that the human race, though recent geologically, is of very great antiquity historically.

We must now shortly consider our third question, as to the bearing of these facts and doctrines on our received views of human chronology, derived from the Holy Scriptures and the concurrent testimony of ancient monumental and traditional history. It is certain that many good and well-meaning people will, in this respect, view these late revelations of geology with alarm; while those self-complacent neophytes in biblical learning who array themselves in the cast-off garments of defeated sceptics, and when treated with the contempt which they deserve, bemoan themselves as the persecuted representatives of free thought, will rejoice over the powerful allies theyhave acquired. Both parties may however find themselves mistaken. The truth will in the end, vindicate itself; and it will be found that the results of such careful scrutiny of nature as that to which naturalists now devote themselves, are not destined to rob our race either of its high and noble descent, or its glorious prospects. In the mean time those who are the true friends of revealed truth will rejoice to give free scope to legitimate scientific investigation, trusting that every new difficulty will disappear with increasing light.

The Biblical chronology, though it allows an unlimited time for the pre-human periods of the earth's history, fixes the human period within narrow limits,though it does this not by absolute statement of figures,but rather by inference from chronological lists, with respect to the computation of which there may be and has been some difference, especially in the antediluvian period. Allowing large latitude for these differences, we have say 2000 to 3000 years for the human antediluvian period, corresponding, it is to be supposed, to the later post-pliocene of geologists. In this period men may have extended themselves over most of the old continent; and it has been calculated that they may have been nearly as numerous as at present, but this is probably an exaggeration.

They had, locally at least, domesticated animals; they had discovered the use of the metals, and invented many useful arts, though there must have been a vast, scattered, barbarous, population. They had split into two distinct races; some portions of which at least, had sunk to a state presumably lower than that of any modern tribe, since these latter are all amenable to the influences of civilization and Christianity, while the former seem to have been hopelessly depraved and degenerate. At the same time they had much energy for aggression and violence ; and it would seem that these giants of the olden time were in process of extinguishing all of the civilization of the period when they were overwhelmed with the deluge. This is described in terms which may indicate a great subsidence, of which the Noachian deluge was the culminating point, in so far as western Asia was concerned. The subsidence, unless wholly miraculous, may have commenced at least at the beginning of the 120 years of Noah's public life, and possibly much earlier, and the re-elevation may have occupied many centuries, and may not have left the distribution of land and water, and consequently climate, in the same state as before. At a very early period of this subsidence, if there were men in Europe, they would be perfectly isolated from the original seats of population in Asia, and so would the land animals, their contemporaries. There is farther, nothing in the Mosaic account to prevent us from supposing that the existence of many species was terminated by this great catastrophe.* These are some of the conditions of the biblical deluge, which we might much further illustrate, were this a proper place for doing so, but those stated will suffice to show precisely in what points the new doctrines of geologists in regard to the antiquity of man, appear to conflict with this old narrative.

When we carefully consider the geological facts, in so far as they have been ascertained, it seems to us that the discrepancy may be stated thus. Reasoning on the geological doctrine that all things are to be explained by modern causes, and insisting on a rigid application of that doctrine, we must infer that the date of the introduction of man was "many ten thousands of years" ago. Adopting the biblical theory, so to speak, that a great subsidence, of which modern history affords no example, has occurred within the human period, we might adopt a very much shorter chronology. It would seem at present that the facts can be explained on either view; and that the possibility of reconciling these views must depend on the greater or less evidence which geologists may find of more rapid changes than they have heretofore supposed within the human period. Our own impression, derived from a careful study of all the facts so well stated by Sir C. Lyell, is that the tendency will be in this direction, that the apparent antiquity of the comparatively insignificant deposits containing remains of man and his works will be reduced, and that a more complete harmony than heretofore between the earliest literary monuments of the human race and geological chronology will result. At present the whole inquiry is making rapid progress, and the time may perhaps be not far distant when its difficulties will receive some such solution. In the meantime both of the writers whose works are noticed in this article, deservec areful study, and will be found to contribute much toward the solution of these great questions. J. W. D.

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* See Archaia, pp. 216 et seq. and pp. 238 et seq. King's Geology and Religion, "Deluge."

ART. XI.—*On the remains of the Fossil Elephant found in Canada;* by E. BILLINGS, F.G.S.

(*Read before the Natural History Society of Montreal*, 23*rd Feb.*, 1863.)

The remains of the Elephant, now in the Provincial Geological Museum, were found in 1852, at Burlington Heights, near Hamilton, at the western extremity of Lake Ontario, about forty feet beneath the surface, and sixty feet above the level of the lake. The workmen engaged in making an excavation on the line of the Great Western Railway, first cut through thirty feet of stratified gravel, composed of small pebbles of limestone, and so strongly cemented that it could only be removed by blasting. Below this gravel, there was met with a deposit of coarse sand; and in this the bones were discovered. The geological age of this deposit is not yet determined with certainty; but is supposed to be that of the well-known lake-ridges and terraces, which were apparently formed just after the close of the upper drift period; and either while the waters of the lake stood at a higher level than they do at present, or perhaps while the basin of the lake formed an arm of the sea.

The following are descriptions of the more important bones found at this locality.

EUELEPHAS JACKSONI. (Briggs & Foster.)

The most perfect specimen consists of the right ramus and the symphysis of a lower jaw, holding a molar tooth in a good state of preservation. The condyle is broken off at the neck, and the angle and wall of the alveolus on the inner face of the jaw are removed, so that on the outside, the lower posterior edge, and on the inside, three fourths of the whole surface of the molar are exposed. The notch between the neck of the condyle and the coronoid is deepened by a fracture.

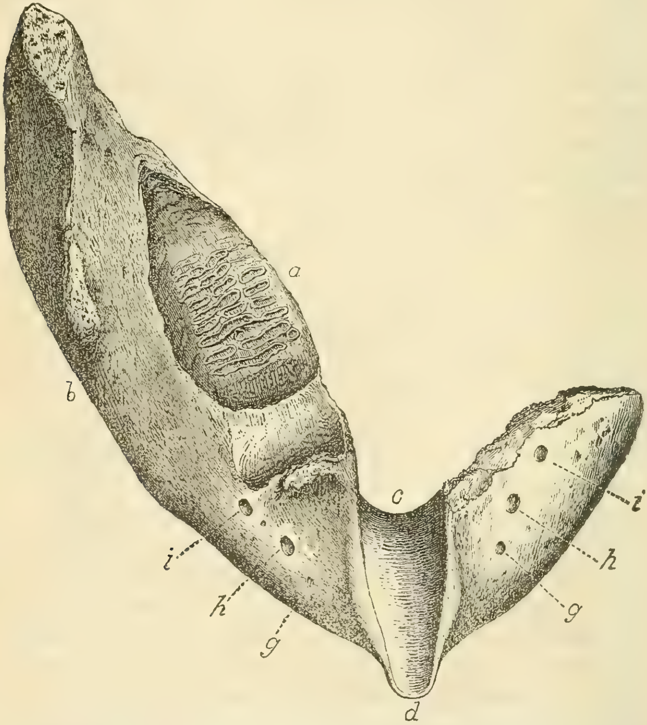

Fig. 1.—EUELEPHAS JACKSONI, (Briggs & Foster,) Right ramus and symphysis with a molar in place.

As nearly as can be ascertained, the length of the jaw, when both rami were in connection, measured along the median line through the symphysis, from the extreme point of the mandible to a plane erected perpendicularly behind the ascending rami, was twenty-three inches. The greatest width across the two rami, from outside to outside, at about four inches in advance of the posterior edges, is twenty-two inches. Length in a straight line, from the posterior side of the neck of the condyle obliquely downwards and forwards to the point of the mandible, twenty-eight inches; from the same point in the neck of the condyle to the anterior margin of the alveolus, twenty inches; from the anterior edge of the coronoid to the anterior margin of the alveolus, eight and three-fourths inches. Height of the ascending ramus, seventeen inches; of the coronoid, twelve inches; of the jaw at the anterior margin of the alveolus, eight and three-fourths inches. There are three pairs of mental foramina. The first or anterior foramen on the right side is three and a half inches; the second, four and a-half; and the third, five and a quarter inches, above the base of the jaw. On the left side

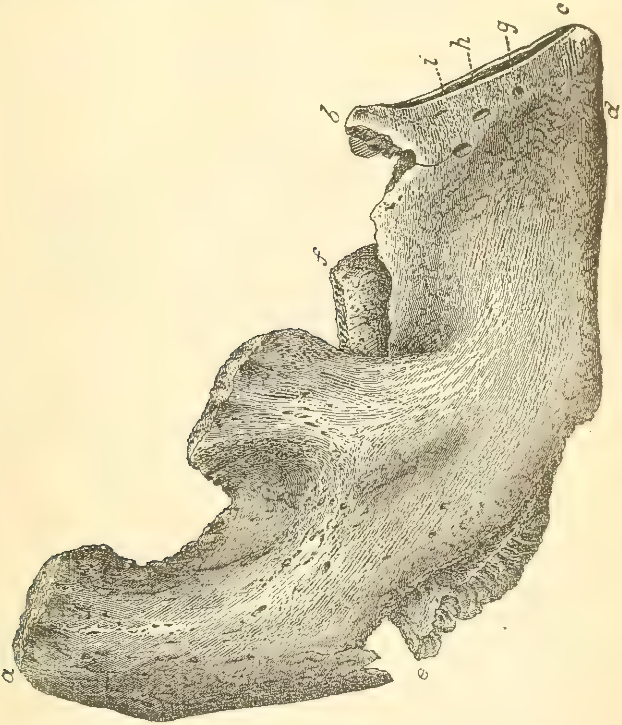

Fig. 2.—Side view of Fig. 1. This figure having been engraved from a photograph does not give the true proportions. Owing to the great convexity of the object the front *d b* is diminished by the strong perspective.

the height of the first is three and a-half, of the second five, and of the third five and a-half inches. The distance through the symphysis, in a straight line between the two foramina of the first pair is five inches; of the second pair, six and a quarter; and of the third pair, nine and a quarter inches. The thickness of the jaw (including the molar) at the anterior edge of the coronoid is eight inches.

The form of the symphysis differs from that of *E. primigenius* as figured by Cuvier, Owen and others. On the underside the

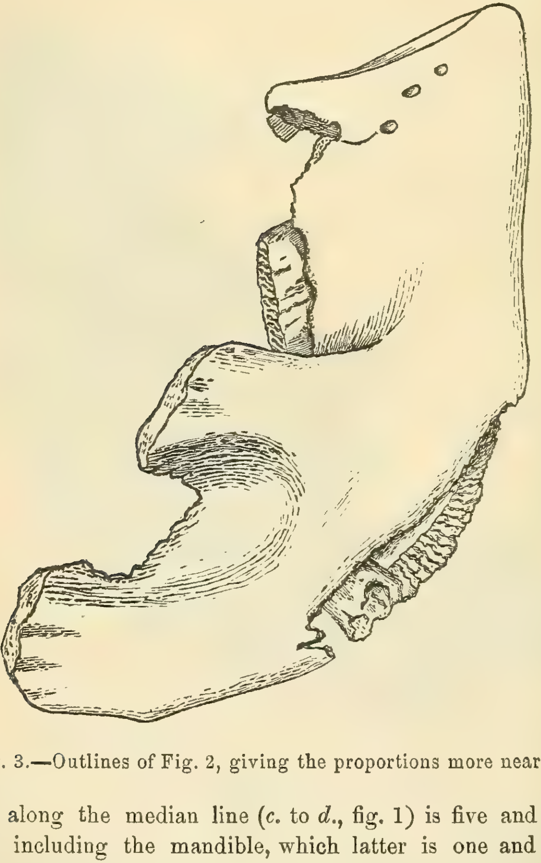

Fig. 3.—Outlines of Fig. 2, giving the proportions more nearly.

length along the median line (*c.* to *d.*, fig. 1) is five and a-half inches, including the mandible, which latter is one and a-half inch in length. The most elevated point of the symphysis, is at two and a-half inches in advance of a line erected perpendicularly from the posterior margin, or nearly half way between *c* and *d*. The height of this point is three and three-fourths inches above the lower surface of the jaw. The bottom of the symphysial gutter inclines forwards and downwards with a straight slope at an angle of about 40° with the plane of the under-surface; but backwards the descent is depressed convex and at an angle of 60°. with the same plane. There is a strong rounded elevated margin on each side, which is about three-fourths of an inch in height and width at three inches from the point of the mandible, but becomes narrower and less prominent both above and below. It (the gutter) is rounded in the bottom; and its width at one inch above the most elevated point of the symphysis is two and one-eighth inches. In front of this point it narrows to three-fourths of an inch at the point of the mandible, where it is also very shallow. Owing to the great height of the jaw, the gutter, on a front view, makes a deep notch between the upper halves of the two rami, having a nearly vertical wall on each side. The depth of this notch is five inches, and its width at the top is two and three-fourths inches. Behind the notch, the inner surfaces of the two rami appear to form two nearly vertical parallel planes, for a distance of about nine inches, separated from each other by a space of between two and three-fourths and three inches. They then diverge from each other with an obtusely rounded curve.

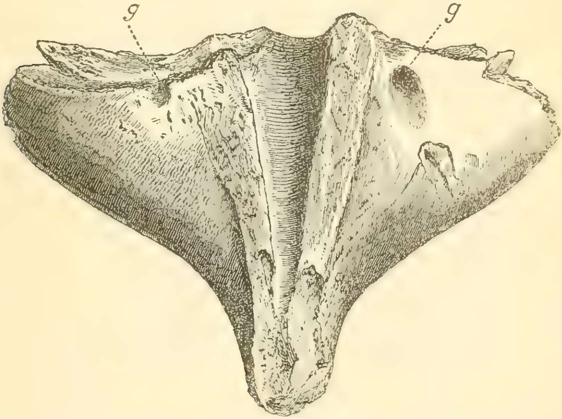

Fig. 4.—Upper side of a symphysis with the elevated margins of the gutter broken away, *g*, *g*, the anterior foramina.

The molar tooth is in a fine state of preservation, and well exposed to view. Its length along the crown is eleven inches; but owing to the manner in which the plates diverge from each other towards the lower side or base, the extreme length, at about two inches below the plane of the crown, is thirteen and one half inches. The greatest width of the crown is at the third plate, where it is three and one fourth inches. It becomes slightly narrower backwards. At two inches below the plane of the crown the width is three inches and seven-eights. There are twenty-six plates, including two incomplete ones at the posterior extremity. The nine anterior plates have been brought into view, and the next two are partially exposed. The nine worn plates occupy a length of four inches, giving an average of a little less than half an inch for each. From the manner in which the plates diverge below the crown, the average width at half the depth of the tooth, as exhibited by the ridges on the side is a little more than half an inch. The enamel plates are thin and not crimped, and both the dentine and the cement are worn out to the depth of one or two lines below them. The height of the tooth at the mid-length is about seven one half inches. In front of it there is an empty fang-pit, four inches in depth, separated from the main body of the alveolus by a thick transverse wall. The tooth is gently curved sideways, having the concave curve outside. The last or posterior plate consists of only three digitations. The next in front of it, of six and the third of seven.

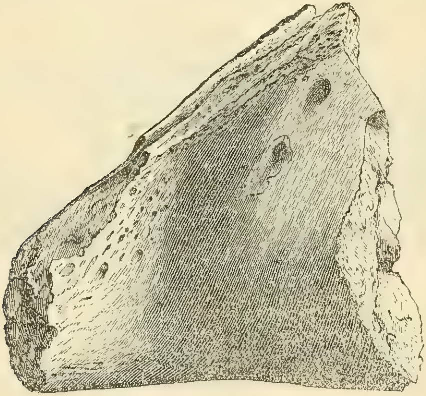

Fig. 5.—View of the left side of Fig. 4.

The next specimen to be described is a symphysis (Fig. 4 & 5), evidently belonging to a much larger animal. The length along the median line on the under surface is six one-fourth inches including the mandible, which is two and one-fourth inches in length and is still not complete; the point having been broken away. The height from the under surface, to the most elevated point in the bottom of the gutter, is four and three-fourths inches. The slope of the bottom of the gutter forwards and downwards forms an angle of 40°, with the plane of the under surface precisely as in the other specimen. But the slope backwards differs in being about 80° instead of 60°. The greatest width of the gutter is one and three-fourths inches. It is bordered on each side by the remains of what was evidently an elevated margin similar to that of the other specimen. The two anterior foramina remain; their height above the plane of the under side of the jaw is five inches distance between them three and three-fourths inches. The greatest width across the broken larger end of this bone is about nine and a-half inches.

Calling the first specimen described No. 1, and the latter No. 2, the difference in their proportions may be thus tabulated in decimal parts of an inch.

	No. 1 Inch.	No. 2 Inch.
Length of underside of symphysis along the median line including mandible,................	5.50	6.25
Length of mandible,...........................	1.50	2.25
Length exclusive of mandible,.................	4.00	4.00
Most elevated point of the bottom of the gutter,.	3.75	4.75
Greatest width of the gutter,..................	2.12	1.75
Height of anterior mental foramina,............	3.50	5.00
Distance between them,........................	5.00	3.75

The most important differences between the two specimens, so far as they can be compared, are, that in No. 2, the symphysis is nearly one third higher, or thicker, in the vertical direction, and has a more abrupt slope posteriorly; the gutter is one fourth narrower; and the mental foramina more elevated above the base and not so far apart.

These two specimens, at first sight, appeared to me to belong to two distinct species, and as such I described them at the time, the abstract of this paper was read before the Natural History Society. But on further study I found that if the whole of the elevated margin of the symphysial gutter of No. 1 were broken away (as it is in No. 2,) the slope of the front part of the symphysis, forwards, would be precisely the same in both, (i. e. 40°) when seen on a side view, as in fig. 5. This would greatly diminish the difference in the aspect of the two specimens. There would yet remain, the greater vertical height of the symphysis of No. 2, and the more nearly perpendicular descent backwards I do not feel myself competent to say whether or not these last mentioned characters are of specific importance in the mammalia.

OTHER BONES.

Along with the above were found :—

1. A fragment of a very large tusk, evidently a portion near the base. It is four and a-half feet in length, seven and a-half inches in diameter at the larger, and five and a-half inches at the smaller extremity. It is curved to a radius of about four feet.

2. Part of another tusk a little over five feet in length. It is rather more strongly curved than the other. Its diameter at the larger extremity is four and a-half inches, and at the smaller three and a-half inches. A portion of it appears to be that part which was inserted into the alveolus as it is hollow to the depth of about three inches. It shews the double curvature characteristic of the tusks of the European Mammoth.

3. Portions of two scapulæ and several fragments of other bones, all, from their size, apparently belonging to the same species.

The jaw No. 1, and the smaller tusk were described by T. Cottle, of Woodstock, Canada West, in the Annals of Natural History [2] vol. 10, p. 395, 1852. See also Am. Jour. Sci. [2] vol. 15, p. 282. He was the first to announce the discovery of mammoth remains in Canada. All the bones now in the Provincial museum were presented by the late R. Benedict, Esq., who was, at the time of their discovery, the Chief Engineer of the Great Western Railway.

REMARKS ON THE SPECIES.

The remains, upon which the species *Euelephas Jacksoni* was proposed, were collected in Jackson County. Ohio, in 1838, by C. Briggs and J. W. Foster; then engaged along with Mr. Mather, in the geological survey of that State. The following is Mr. Briggs, account of the discovery :

"About two years ago, some bones, so large as to attract the attention of the inhabitants, became exposed in the bank of one of the branches of Salt Creek, in the northwest part of Jackson County. They were dug out by individuals in the vicinity; from whom we obtained a tooth, a part of the lower jaw, and some ribs.

"In the examinations at this place, during the past season, it was concluded to make further explorations, not only with the hope of finding other bones, but with a view of ascertaining the situation and the nature of the materials in which they were found. The explorations were successful. There were found some mutilated and decaying fragments of the skull, two grinders, two patellæ, seven or eight ribs, as many vertebræ, and a tusk. Most of these are nearly perfect except the bones of the head. The tusk, though it retained its natural shape as it lay in the ground, yet, being very frail, it was necessary to saw it into four pieces, in order to remove it.

"The following are the dimensions of the tusks, taken before it was removed from the place in which it was found :

Length on the outer curve	10	feet	9	inches.
" " inner curve	8	"	9	"
Circumference at base	1	"	9	"
" 2 feet from base	1	"	10	"
" 4 feet from base	1	"	11	"
" 7½ feet from base	1	"	7½	"

"This tusk weighed, when taken from the earth, 180 lbs. The weight of the largest tooth is 8¼ lbs. These bones were dug from the bank of a creek, near the water, where they were found under a superincumbent mass of stratified material fifteen to eighteen feet in thickness." (See the 1st Ann. Rep. Geol. Soc. Ohio, p. 97, 1838.)

In November, 1838, there was published in the Am. Jour. of Sci., vol. 34, p. 362-3, a letter, apparently written by one of the discoverers of the remains in question, in which the difference between the form of the jaw and that of *E. primigenius* was pointed out and illustrated by two figures. His remarks are, in substance, that the jaw of *E. Jacksoni* "converges more," or is not so broadly rounded in front, and that the symphysial canal is much narrower than in *E. primigenius*. The figures, it is evident, were only intended for a mere diagramatic illustration, and are therefore not very neatly executed. But taken together with the letter, they constitute a very important contribution to science, as they afford the first proof ever published, that there is in America a fossil elephant different from the European and Siberian *E. primigenius*.

In the original figure of the jaw of *E. Jacksoni*, above alluded to, the form of the symphysis and gutter agrees so nearly with that of the corresponding parts of our specimens that no specific differences can be perceived. The molar teeth, represented in their place in the jaw, do not appear to be correctly drawn, as they differ from each other in their proportions and in the number of plates. On the same page, however, there is a figure of the crown of one of the molars, and in the 36th volume of the Journal, p. 190, Mr. Foster gives another and a better one, of the same tooth; but he does not state on what scale it is drawn. The length of this latter figure is three and a half inches and one and a half in width. Assuming this to be half the natural size, the length would be seven inches and the width three. There appear to be fifteen plates, including four at one end which are represented by irregular rows of digitations, more or less worn. This would give an average of a little less than half an inch to each plate, thus agreeing exactly with the Canadian molar.

The tusk described by Mr. Briggs differs from our specimens in being less curved; but this is a character upon which a great deal of reliance cannot be placed. The tusks of all the species of elephants vary to a considerable extent, not only in the amount of their curvature but in their size. Three tusks have been lately procured from the Youcon river, in Arctic America, by B. R. Ross, Esq. Two of these are curved, but the third is nearly straight, The characters of the molars seem to be more permanent.

At Zanesville, in Ohio, there was found, in 1852, the skeleton of an enormous elephant, having the tusks and the four molar preserved.

These were described by Prof. J. Wyman, in the Proceedings of the American Association, published in 1857.

"The following are the dimensions of the right and left upper molars in inches :—

	Right.	Left.
Greatest length	14¼	13½
Greatest height when resting on the ground.	10½	11
Length of grinding surface	8¾	9
Breadth of " "	4¼	4¼
Whole number of plates	29	30
Plates of grinding surface	18	18

The dimensions of the molars of the lower jaw are as follows :

	Right.	Left.
Whole length	14½	15
Length of grinding surface	9	8¾
Breadth " "	3¾	3½
Whole number of plates	24	25
Plates of grinding surface	17	17

Comparing the average width of the plates of the grinding or worn surfaces of the above four molars with that of the Canadian specimen, and also with that of *E. Jacksoni*, as figured by Foster (assuming that his figure is half the natural size), the following are the results in decimal parts of an inch:

	Average Width.
Right upper (Wyman)	·49
Left upper "	·50
Right lower "	·53
Left lower "	·52
Right upper (Foster)	·46
Right lower (Billings)	·44
The first thirteen plates of the same at two inches below worn surface	·51

In the Zanesville molars, there were eighteen plates in the upper, and seventeen in the lower, brought into view. Consequently the average width of the plates, on the worn surface, is greater than it would be if only nine plates had been brought out to view by wear, as in our specimen.

According to the views of Mr. Foster, as given in the Proc. Am. Assoc. above cited, the remains of the Ohio elephants were found in a deposit accumulated just after the close of the northern drift period, and while the river terraces were in process of formation. The individual, to which the four molars described by Prof. Wyman belonged, was discovered in an ancient shore of the Muskingum River, in what he, Mr. Foster, calls valley drift, being composed of loam sand and gravel filling up the original valley of the stream that had been excavated out of the palæozoic rocks. This valley drift holds large blocks of rock; evidently transported, but derived from the neighboring carboniferous and Devonian formations, over which the river flows. These blocks were most probably floated, not by icebergs, but by river ice, at a time when a somewhat colder climate prevailed in the Western States. Some of these blocks were found, immediately above the stratum of sand holding the elephant's bones. I believe this valley drift to be of the same geological age as the formation of sand gravel at Hamilton in which our specimens were found. On comparing all the evidence—namely, the figures and descriptions published by Briggs and Foster, the measurements of the teeth given by Prof. Wyman, the proximity of the localities and the probable identity in geological age of the valley drift and lake terraces,—I think it almost certain that the four elephants above noticed are all of the same species, *E. Jacksoni.*

I have no means, except the figures published by different authors of comparing *E. Jacksoni* with *E. primigenius.* Dr. H. Falconer in an article, (extraordinary for the amount of valuable instruction it contains) published in the Natural History Review for January, 1863, points out that the American molars, referred to *E. primigenius*, differ from those of the European form of that species, in having the plates more numerous in proportion to the length of the teeth. He also says (p. 67 Op. cit.) that the figure of the lower jaw of *E. Jacksoni*, above mentioned, indicates a different species. But he was evidently not aware that the molars in question and the jaw belong to the same. Our specimens set that question at rest. The figures 4 and 5 Pl. 11, Cuvier's Ossimens Fossiles represent two lower jaws of *E. primigenius.* Fig. 4 is one-eighth of the natural size, and shews a symphysial canal 8 lines wide, giving 5⅓ inches for the width of it in the original. That of Fig. 5 had a canal 4 inches wide. The width of the same organ in our two specimens of *E. Jacksoni* is 2⅛ and 1¾ inches respectively. This difference is so great that, could we compare entire animals or skeletons of both species we would, in all probability, find corresponding differences throughout their whole frame. The difference in the molar teeth is not so great, but still it is such that it gives, as Dr. Falconer says, "a certain amount of distinctive physiognomy." By itself it would not, perhaps, amount to much; but when taken in connection with the difference in the form of the symphysis it becomes important.

It seems quite certain that there are several species of American fossil elephants, but the question, how many? remains yet to be decided.

The following have been indicated, but much yet remains to be done before the Synonymy can be clearly settled.

1 *E. primigenius*, (Blumenbach).
2 *E. Jacksoni*, (Briggs & Foster) 1838.
3 *E. Rupertianus*, (Sir J. Richardson) 1852.
4 *E. Americanus*, (Leidy) 1853.
5 *E. Columbi*, (Falconer) 1857.
6 *E. Imperator*, (Leidy) 1858.
7 *E. Texanus*, (Blake? or Owen) 1858.

The last three are clearly distinct from *E. Jacksoni*, but are they distinct from each other? I have seen no description of *E. Americanus.* Dr. Falconer says that Sir J. Richardson has withdrawn *E. Rupertianus* from the list, having become aware by his own researches that it is not separable from *E. primigenius.*

Should it be admitted that *E. Jacksoni* is distinct from *E. primigenius*, then, we have no proof whatever that this latter species ever lived so far south in America as the United states and Canada. A large proportion of the remains, found in these two countries, which have been heretofore referred to *E. primigenius*, most probably belong to *E. Jacksoni.*

No Remains of Man Found.

No remains of man, or of his works, have been found in the formation which holds the bones of the Elephant in Canada. In allusion to the absence of human bones in the ancient river drift of Europe, I may mention, that for the last fifteen years, I have been in the habit of examining the bottom of the Ottawa and other Canadian rivers every season, at the time of the lowest water, in search of fossils; and that, although I have seen the bones of almost all the species of land animals now living in the country, associated with innumerable works of man, I never yet found a human skull in any of these streams. I speak of the skull, because it is possible that some of the small bones may have been those of the human frame, and not recognized as such by me. But, as man is the only animal who removes the dead of his own species from the water, and buries them on shore, thousands of years may elapse without a single skeleton being imbedded in a fluviatile formation; and yet the same formation may be full of the traces of his existence, associated with abundant remains of contemporary animals.

Art. XII.—*Remarks on the Genus* Lutra, *and on the Species inhabiting North America;* by George Barnston, Esq.

(*Presented to the Natural History Society.*)

The purpose of this paper is to introduce to the notice of naturalists a rare variety, in all probability, I may say, a distinct species of otter, yet undescribed by zoologists, and smaller than the common otter of Canada. Experienced Indian hunters know it as a different animal, applying to it the name of the pulling-down otter. In the Ojibiway tongue this term is *Pinaikiwawkeek*, or *Pinahaikiwawkeek*, which I have followed in adopting for it the specific name of *Destructor*.

A few prefatory remarks on the number of the species of the genus *Lutra* generally may not be uninteresting.* The materials within my reach do not allow me to enter into many particulars; but I can touch upon the names of six or seven species mentioned by travellers as occurring in different quarters of the globe. Following such information we find otters of different kinds on the four great continents.

First, we have the *Lutra vulgaris* of Great Britain and Europe; with what is considered a dark or black variety of the same on the sea coasts. This is called *L. Roensis* by Ogilby, who deemed it distinct, and who had it from the shores of Antrim in the north of Ireland.

India has its otter in the *Lutra Nair*, the Nir Nayie, which in some parts of that country is domesticated, and rendered very serviceable by being taught to drive fish, and even take them in the water and bring them on shore for the fishermen. No doubt the Nir Nayie brings the fish ashore for his own use; but the fisherman interferes, the rights of the biped coming before those of the quadruped. The Juhl Margur of the Mahrattas is perhaps only a variety of the Nir Nayie. It is a little larger, and differs in wanting the white spot over the eyes, and in having a white upper lip. It may be found however, upon a full anatomical comparison, that these two otters are of distinct species.

The Javanese Simung is a species of otter to which Horsfield, so well known as an ornithologist, gave the name of *Lutra leptonyx*, or fine-clawed otter. Opinions vary as to whether this may not be similar to, or a variety of the otter to which I have next to advert; but the wide separation of the two countries by ocean, and the almost total if not entire difference of their mammals in other genera, would favor the opinion that their otters are distinct also.

The *Lutra Capensis* was constituted a genus by Lesson, under the name *Aonyx*, as wanting claws, a peculiarity pertaining to some specimens had from the Cape, but which has not been determined as in all instances constant. It would appear that such a character would require a number of specimens in proof, ere naturalists could admit it as always existing and permanent, so as to entitle it to generic pre-eminence. It is possible there may result a solution of these difficulties in the determination of two distinct species of otter on the southern portion of the African continent.

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* Audubon gives a list of 11 species enumerated by authors, viz :—"Europe, 1; Island of Trinidad, 1; Guyana, 1; Brazil, 1; Kamschatka, 1; Para, 1; Malay, 1; Pondichiery, 1; The Cape of Good Hope, 1; and North America, 2." Pennant seems to have considered the North American and Kamschatka Otter as the same, and the names Guyana, Trinidan, Brazil, appear merely local, not distinctive, in the absence of specific characters, which I regret I cannot here obtain.

The *Lutra Brasiliensis* of Ray is the *lobo du rio* of the Portuguese and Brasilian colonists. This appellation of River Wolf is given to it, we may conclude, from the barking noise it makes, and from its gregarious habits. These otters keep together in bands, but have no resemblance to the wolf. Azara's name is *Nutria*, and it is a well marked species, smaller than our Canadian otter, of a yellow colour, and destitute of the glandular apparatus round the nostrils; which is the only portion of the nose wanting hair. In our North American otters a large space on the nose is bare. As might be implied from its gregarious habits, the Brasilian otter has a social disposition. They fish in company in the rivers of Paraguay and Brazil, and many females rear their young together in one locality.

Lutra Californica is a species established by Mr. J. E. Gray of the British Museum, on the strength of its differing from the Canadian Otter, in having but little hair on the feet between the pads of the toes, and less on the palms and soles generally. Besides this, the length of the naked portion of the nose is shorter than its breadth, and shews not anteriorly or posteriorly the acute points encroaching upon the upper lip and forehead. These marks, especially the latter, are quite observable in the case of the Canadensis, and probably are the consequences of a difference in the nasal bones. Zoologists therefore have been induced to follow Gray, and adopt the species. Indeed the separation of California from the rest of our continent by the high lands of Mexico, with their characteristic Fauna and Flora, on the east, the sandy deserts and the Elk and Humboldt mountains, on the north east, and the gigantic southern limbs of the Cascade range, on the north, renders it probable that this otter, is distinct. When a number of the skulls and skeletons of each shall have been collected, a close comparison will decide the matter.

Eastern North America, which is so highly favored in the possession of magnificent rivers and lakes, filled at times to overflow by a thousand tributary streams and mountain torrents, might well be supposed to abound in otters, and such is really the case, where civilization with its attendant population has not thinned their numbers, or entirely rooted them out. In flat level districts, where streams are numerous, and well provided with boulders and rolled rocks, localities to which otters appear partial, as affording secluded and safe retreats, an able Indian hunter has been known to kill forty or fifty in the course of a winter and spring. The *Lutra Canadensis*, which affords this sport, is found across the whole of the continent, and the animal differs little on the western slope from what he is found to be on the eastern side. From recollection I am disposed to think that on the waters of the south branch of the Columbia, and the rivers lying between that and the Pacific, its fur, like the coat of the beaver, is lighter colored than in the colder regions.

In winter, otters, like seals, are fond of coming upon the ice, but always in the vicinity of open water, into which they can easily plunge on the slightest alarm. In the spring they extend their walks, and disport themselves on the ice, especially after a light fall of snow. On these occasions they frequently fall by the hunter's gun. When greater excursions are made, as in crossing through woods from one stream to another, or traversing large lakes to reach open currents, otters seem to glide along, as it were, in their course, and this is done by repeated jerks forward. In deep snow scarcely any traces are left of the feet, the weight of the body following erasing the impression. The appearance afterwards is exactly as if a heavy cylinder, the size of a stove-pipe had been moved along by some invisible power. These long journeys are made principally in the earliest warm days, when otters begin to change their winter haunts, and seek for mates. At this period hunting is followed up with the greatest success. The Indian is constantly on the look-out for these animals, when they leave their holes to pass through points of woods and over frozen lakes, in search of their companions, and of other quarters where fish begin to collect. In deep snow the difficulty of overtaking them is lessened by using the snow-shoe, and when a frozen lake occurs, where the crust is hard or the ice bare, the snow-shoe is dispensed with, and the animal soon overtaken, if there be no open water at hand. The mode of progression of the otter by jerks, or a repeated succession of forward impulses, is occasioned by the shortness of its legs, and the compact firmness of its hind joints, best adapted for swimming. In fact they do swim on the surface of soft snow, their smooth fur opposing no obstacle to their advance, but rather aiding them on declivities, where their pace becomes accelerated. A hunter needs to be quick when an otter is shot in or near to the water. The moment it is dead it sinks like a seal; and if not badly wounded it escapes without difficulty unless seized immediately.

The female otters are smaller than the males. March and April is the season of gestation, and in August the young are active and able to provide for themselves. In northern latitudes the season of pairing may be a little later. Their principal food is fish, but they eat also mollusks and crustacea; unios and crawfish abound in some streams, and afford them much sustenance. At fishing stations they are particularly troublesome, and very expert in eluding the snares devised to catch or entrap them. They destroy many more fish than they eat, preferring always the head, and often leaving the rest untouched. When the nets are watched, during the day, they make their visits in the darkness of the night and retire unperceived to holes in the bank, under the roots of trees and similar places, where they remain in comparative safety. When there is a scarcity of fish and otters are numerous, their depredations are very damaging.

If trouble be taken with the otter to tame it, it becomes a very interesting pet. There is something mischievously amiable about a pup otter. Restless and wary he gets into every hole and corner, his tone of voice is agreeable, and the soft glossiness of his black coat would induce any one to pat or caress him. I kept one for some time, and it afforded great amusement. When taken to the borders of the river, it would seek a pool or eddy of considerable depth, where it would commence diving, bringing generally from the bottom some species of small mollusk. Shells of the cyclas genus were very abundant there. These it would crunch and eat, one at a time, holding the nose and mouth out of the water the body being apparently almost in an upright position. As soon as one was finished, it would dive again without delay to the bottom, returning to the surface as soon as another cyclas had been got, never seeming to tire of the amusement. This hard exercise appeared to occasion no fatigue; and as a hearty breakfast of fish had been had before hand on shore, the entertaiment no doubt was equivalent to a dessert and a bath.

With harder shells an otter has greater difficulty; with an anodonta or unio he seeks some rock shelving into the stream, or a flattish stone or rolled boulder just appearing above water, or but slightly covered; here he makes his repast, breaking the shell and, eating its contents. In navigating rivers with boats or canoes, rocks and flat stones, on or near the surface, may be frequently observed with collections of open and shattered shells upon them; indicating the spot to which an otter had resorted for the purpose of dining, a board where he could best get over the troublesome process of getting into the dish. These dinner-tables of the otter are worthy of the conchologist's regard, as likely to furnish occasionally a rare bivalve.

The remarks just made, although drawn from observation of the habits of *Lutra Canadensis*, are applicable, I daresay, in a great measure, to the other otters; and we now arrive at the more particular consideration of the *Lutra destructor*. I purpose to show that there exists throughout a great portion of the British territory in North America, if not farther south, a smaller species of otter, well known to the aboriginal Ojibways and the Crees, as the *Pinaikiwawkeek*, the breaker of beaver-houses and dams. He closely resembles the larger otter in dentition, color, and shape, but is of more slender structure, and possesses marked differences in the proportions of the cranial bones. He has besides distinct habits, and modes of life, especially in his search for sustenance, which I think altogether entitle us to consider him as specifically separated from the *Lutra Canadensis*.

Through the kindness of Professor Baird, of the Smithsonian Institution, I have been favored with drawings of the skulls of the English otter, *Lutra vulgaris*, and of *Lutra destructor*, the latter taken from a specimen sent by me to the Institution about eighteen months ago. A comparison of these shows differences so striking, that we cannot entertain an idea of their belonging to the same species, and we are thus left to the investigation of the points of variance between the *L. destructor* and our own otter, *L. Canadensis.*

The *Pinaikiwawkeek* or pulling-down otter, attains the length of from thirty-six to forty inches, about the size of the smallest females of the *Lutra Canadensis*, but nearly a foot shorter than the largest males. From many measurements of two specimens of the two species, of nearly equal size, it will be perceived how closely in some respects they resemble each other, yet in other particulars how they unaccountably disagree. This disagreement in the measurements before skinning, as shown in the accompanying table, is perhaps more strikingly illustrated by an examination of the skulls; and accords with remarks I have heard made by Indians of the appearances by which they distinguish the one otter from the other. In the *L. destructor* the bones of the skeleton and the cranium are less massive. The length of the skulls being nearly alike (as in the two specimens taken for exemplification), there is found in the *L. destructor* a less breadth in the post-orbital process of the frontal; and the whole of the nasal bones are narrower and weaker. The outer measurement of the cavity of the brain approaches the oval, being convex in all aspects, and it exceeds the half of the total length of the skull from occiput to incisors, by nearly one-fourth of an inch; whereas the enclosing shell or covering of the brain in the *L. Canadensis* is almost exactly half the length of the whole skull. It is also nearly flat on the top, presenting no rounded surface except close to the occiput: this feature also prevails, although to a less extent, laterally, and there is a more sudden and decided narrowing of the cavity anteriorly, so that the general outline approximates less to ovaliform, and more to the shape of a truncated cone.

On the lateral view, with the lower jaws taken off, the skull of the *L. destructor* exhibits somewhat of an arched appearance; the molar and facial bones are narrower, and the zygomatic arch rises to about half the height of the skull. In the *L. Canadensis*, on the same lateral aspect, the planes of the head are straighter, the facial bone deeper and broader, and the zygomatic arch rises only to a paralled line of two-fifths of the depth of the skull. Here I may observe that the smallness of the bones of the face in the *L. destructor*, coincides with the remark I have heard made by a hunter, that the eyes of the *Pinaikiwawkeek* were closer to the end of the snout than in the common otter.

These differences, drawn from measurement and osteological characters, would not have determined me to have reckoned these two otters different species, (although deviations of less note have often served for specific separations,) but the account given by Indians of their *Pinaikiwawkeek*, not only to myself, but to others, tend to impress upon me the conviction that in it we have a different animal from the common otter of America. That the beaver, in spite of his size and strength, at times falls a prey to the otter is certain. In 1823, I accompanied a few Churchill Crees, in order to be present at the taking of a beaver-lodge. After breaking through about three to four feet of frozen mud with their ice chisels, they found the lodge empty. The lodge being large, I was able to descend into it, and crawl about on all-fours. At the door, situated opposite the middle of the little shoal-lake in which the beavers had built, I found vestiges of old cut willows scarcely thicker than the fingers. The door had been under water, but the floor rose towards the centre of the house, so that it must have been partially dry in summer. The ice was at its upper surface higher than the opening or door towards the lake, but the water having either retired or been drawn off, it was hollow beneath; and although the situation was shoal, a beaver nevertheless could have crept under. I was much interested about the structure of the lodge, and especially with one or two niches in the wall, a little above the level of the floor, which I looked

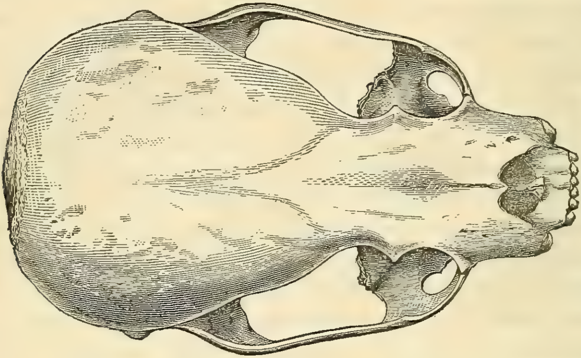

Figure 1.

L. destructor; top view of skull three-fourths natural size.

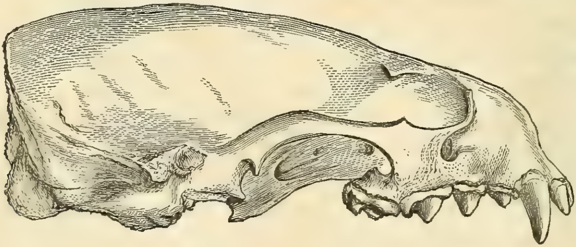

Figure 2.

L. destructor; side view of skull three-fourths natural size.

upon as seats, or places of retirement, if at any time the rising of the water should overflow the basement. Some such provision for accidents was without doubt had in view in the construction of these lowly arched niches, which certainly afforded more room to the family. Being scarcely acquainted with the Cree language at that period, I could not interrogate the hunters closely; but after they had surveyed the surrounding locality, and examined the lodge, they gave it as their opinion that an otter had been there to spoil their sport and destroy the beaver.

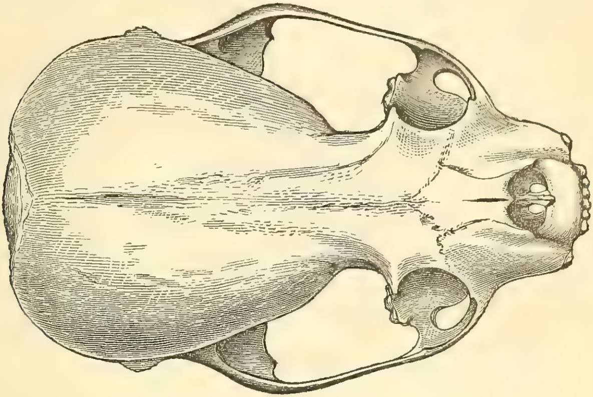

Figure 4.

L. Canadensis; top view of skull three-fourths natural size.

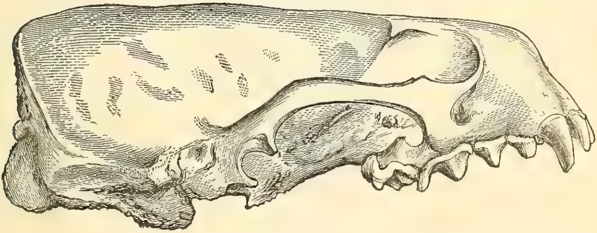

Figure 5.

L. Canadensis; side view of skull three-fourths natural size.

In 1835 I first began to make particular enquiry regarding the destruction of beaver by otters. This was on the Albany river, and the Indian interrogated was an elderly man, not one of the best of characters, but he had always been most friendly to me, and was most shrewd and intelligent. He was deemed a conjuror by his tribe, and bore that name at our establishment amongst the servants. I was told by him that it was the small otter, which he styled *Pinaikiwawkeek*, that killed the beavers, by breaking down their dams and getting into their houses; or so disturbing them as to take them at disadvantage abroad, devouring the young, and all he could succeed in mastering. Had this animal been the young of the Canadian otter, it would have been named *Neekeekous*, *i. e.* the diminutive affix would have been used with *Neekeek.*

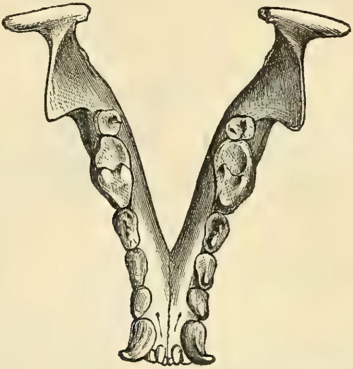

Figure 3.

L. destructor; lower jaw three-fourths natural size.

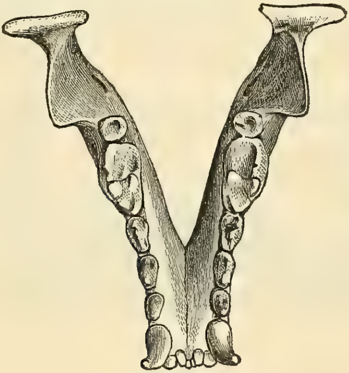

Figure 6.

L. Canadensis; lower jaw three-fourths natural size.

From that period I have always thought we had two species of otter. I was informed at the same time that the *Pinaikiwawkeek* did not consort with the *Neekeek* but that the two were at enmity with each other, and fought when they met. It can scarcely be imagined that this very unamiable disposition, and the destructive habit of destroying the beaver, with the fatigue necessarily attendant upon such a pursuit, could be possessed by a mere variety of the *Neekeek* or common otter, while the same inclinations were not ascribed to every individual of the species. Neither can it be supposed that the young and smaller individuals of a species would follow an occupation requiring apparently a greater amount of intelligence and skill, if not of strength, while the older and stronger members of the same family left it off, or generally declined it. This would be contrary to nature, as displayed in the order of carnivorous animals. It may be also observed that had the two animals been the same, the remark could never be made by Indians that they were obnoxious to each other, and did not commingle or associate together.

Judging from the skull of the *L. destructor*, its greater comparative fulness or roundness of outline, indicating a greater amount of brain anteriorly, and a development of higher instincts,—any one might infer it to be a creature endowed with more sagacity than the common otter; and we find accordingly that, besides the usual fishing occupations, it resorts to war upon the industrious and harmless beaver, and brings into the field a degree of design, contrivance, and perseverance, not belonging apparently to either the *Lutra Canadensis*, or any other of the genus. Not to be tedious, I shall only add, that the information of the Albany and Weenusk Conjuror has been confirmed by many hunters on the shore of Lake Superior, who never saw the Albany river, and who never moved to any great distance from the great lake; and also by communications from a gentleman, who had similar statements from Indians on the shores of Hudson's Bay.

Agassiz says in his very useful work on classification " that " Species in a natural genus should not present any structural " differences, but only such as present the most special relations " of their representatives to the surrounding world, and to each " other. Genera, in one word, are natural groups of a peculiar " kind, and their *special* distinction rests upon the ultimate details " of their structure." I believe there is exhibited in the skull of the

L. destructor a *special* distinction resting on the *ultimate* details of its structure; a speciality is also displayed in relation to the outward world, by the breaking of beaver-works, and preying upon that animal. Another speciality is its non-association with, or enmity towards the other otter. Its isolated mode of life may be deemed a third; and its allowed inferior size a fourth speciality, apart from structural details.

A sufficient amount of data and information has been adduced, I think, to authorize the introduction of the *L. destructor* as another and distinct species of otter, inhabiting in small numbers the region of North-eastern America. If the grounds appear too slight for the substantiating specific impress, I hope that, in course of time, further inquiry and better examination by practical zoologists will decide the point, as well as add to our stock of zoological knowledge.

Differences in Measurement of Two Otters.	Lutra destructor 28th Dec., 1861.	Lutra Canadensis January, 1862.
	Inches.	Inches.
Total length from point of nose to end of tail..........	36.20	38.25
Length from " " to root "	23.25	24.00
Height of hairy portion of upper lip....................	.62	.65
Breadth from angle to angle of mouth beneath, across the lower lip from jaw to jaw......................	2.00	2.20
Breadth of expanded forepaw..........................	2.60	2.75
Breadth of hind sole at callosities....................	1.75	2.00
Breadth of expanded hind foot, from point of the first toe to point of the fifth..................................	3.25	3.50
Breadth of muzzle behind the nose....................	1.75	1.90
" from point of one eye to point of the other......	1.60	2.00
" of head at opening of the ear....................	3.25	3.75
Circumference of head at the ear......................	8.12	9.25
" " " at the eyes......................	6.12	6.50
" " neck at three inches from the ear.....	9.50	10.50
" " body at shoulder......................	13.00	14.00
Length of head from occiput to point of nose..........	4.75	4.75
" from eye to the nostril........................	1.00	1.10
" " " to point of snout......................	1.50	1.60
" " " to entering angle of bare portion of nose on forehead..	1.12	1.25
Circumference from point of snout to auditory opening..	3.60	3.90

Note.—The wood-cuts illustrating this article were drawn on the blocks by Mr. H. S. Smith and engraved by Mr. J. H. Walker.

Addendum to Dr. Dawson's article on Air-Breathers of the Coal Period.

Through the kindness of the Council of the Geological Society of London, the fine skeleton of *Dendrerpeton Acadianum*, sent by me to the Society in 1861, has been returned for my inspection in the preparation of this article.

I am now able to state, in addition to the facts already published, that the large furrowed teeth of the inner series were not placed in the palatal bones, but on the maxillaries and intermaxillaries, the outer series of smaller and simple teeth being borne on the outer margin of these bones. The arrangement was thus somewhat similar to that in *Lepidosteus.* Immediately within the large teeth were the vomerine series, which were very numerous and irregularly placed, but small, with the exception of a few in front. They extended backward in two lines along both sides of the palate, in this also resembling some ganoid fishes.

In this specimen, the lower jaw, remaining in place under the skull, is seen to contain, especially toward the front, long furrowed teeth like those of the upper jaw, implanted in round sockets on the broad upper surface of the mandible, with others more simple and of smaller size.

By carefully removing the stone, I have uncovered the occipital condyles, which are double and square in outline, much like those of *Labyrinthodon*, and not dissimilar from those of *Sieboldia* and *Menobranchus.*

Near the skull, the scales of the throat remain in their natural position, and are seen to be densely imbricated, and arranged in curved rows, diverging from the mesial line. The scales of the abdomen are of larger size, and are scattered over the stone. Those of the throat are of a narrow ovate form, those of the abdomen wider, and some of them tending to rhomboidal in outline.

Twenty-four vertebræ, in all, are seen in the specimen. Of these thirteen occur in continuous series, and appear to be lumbar. They are of small size, relatively to the dimensions of the head and limbs, and indicate a weak and flexible back. Other vertebræ, not in regular series, are dorsal, and have strong transverse processes with oblique articulating surfaces. A few are perhaps cervical and caudal. The bodies of the vertebræ have continuous bony walls, but thinner than in specimens of larger size.

One half of the pelvis is well preserved, and shows a broad ileum, and strong ischiac and pubic bones. There are also broad scapular, and probably sternal bones, but crushed and imperfect. Few of the ribs remain, and these apparently only the smaller ones, as compared with other skeletons of which I have portions.

Several of the bones of the limbs remain in sufficiently good preservation to allow of measurement of their size. I am thus enabled to give the following dimensions of parts of the animal.

Total length of skull,........................	$2\frac{9}{12}$	inches.
" breadth " at the orbits,*............	2	"
Length of humerus,........................	$1\frac{4}{12}$	"
" " ulna,................................	1	"
" " femur,..............................	1	"
" " rib,................................	$\frac{9}{12}$	"
" " eleven vertebræ in series,............	$2\frac{3}{12}$	"

It would seem from these dimensions that the head was broad, and the trunk slender; the anterior limb, including the foot half as long again as the head, and the posterior limb rather smaller or shorter than the anterior. It would thus appear that while the general form of the body was not unlike that of *Menobranchus*, the limbs were much larger, and must have carried the trunk without allowing any part of it to touch the ground, as would also seem to have been the case from the footprints found in the coal-formation beds, and the size and form of the toes of which make it likely that they belonged to this animal.

The limb-bones, though thin-walled and often crushed, evidently had broad articulating surfaces; and in the base of the fore-limbs particularly, were large and strong in proportion to the dimensions of the head and vertebral column.

The large size of the fore-limb I suppose to have been related to a habit of walking or standing in shallow water, with the snout in the air, in the manner of newts, and the more rapid movements of the creature were probably performed by the tail. It is interesting to observe that in *Hylonomus* the proportions of the limbs were reversed—the hind limbs being much larger than the fore limbs.

From the relative dimensions of the bones, as compared with those of other specimens in my possession, I presume that this individual was three-fourths grown, and I doubt if its total length much exceeded one foot.

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* Perhaps increased by flattening.

RAIN.
Amount of, in inches.
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MONTHLY METEOROLOGICAL REGISTER, ST. MARTINS, ISLE JESUS, CANADA EAST, (NINE MILES WEST OF MONTREAL,) FOR THE MONTH OF AUGUST, 1862.

Latitude, 45 degrees 32 minutes North. Longitude, 73 degrees 36 minutes West. Height above the level of the Sea 118 feet.

BY CHARLES SMALLWOOD, M.D., LL.D.

Day of Month	Barometer—corrected and reduced to 32° F. (English inches.)			Temperature of the Air.—F.			Tension of Aqueous Vapour.			Humidity of the Atmosphere.			Direction of Wind.			Horizontal Movement in 24 hours. In miles.	OZONE. Mean amount of, in tenths.	RAIN. Amount of, in inches.	SNOW. Amount of, in inches.	WEATHER, CLOUDS, REMARKS, &c. &c. [A cloudy sky is represented by 10, a cloudless one by 0.]		
	6 a. m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m	6 a. m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m.					6 a. m.	2 p. m.	10 p. m.
1	29.914	29.894	29.831	60.1	85.1	72.0	.456	.775	.601	.88	.65	.78	N. E. by E.	N. E. by E.	S. by E.	60.00	2.0	....	....	Hazy.	Cum. Str. 2.	C. Cirr. Str. 4.
2	794	753	832	60.1	89.9	68.5	.456	.894	.642	.88	.64	.92	W. S. W.	S. W.	S. by W.	22.80	2.5	....	....	Fog.	C. C. Str. 6.	Clear.
3	853	818	814	65.1	92.0	73.3	.583	.768	.617	.94	.51	.77	S. by E.	S. S. W.	S. S. W.	2.80	2.5	....	....	Fog.	Cu. Str. 4.	Str. 2.
4	797	748	832	68.1	93.6	76.5	.543	.755	.765	.79	.48	.84	S. by W.	S. by E.	S. W.	64.20	1.0	....	....	Cirr. 2.	Clear.	Hazy. Aur. Bor.
5	680	615	724	70.1	89.0	70.1	.592	.802	.557	.83	.57	.77	S. by W.	S. S. W.	N. N. E.	142.70	2.0	....	....	Cirr. Str. 2.	C. C. Str. 4.	Clear.
6	863	859	796	61.1	79.2	64.3	.396	.658	.563	.79	.67	.94	N. N. E.	N. N. E.	N. N. E.	56.50	1.5	....	....	Clear.	Cirr. 2.	Cu. Str. 4.
7	30.005	886	830	57.6	89.1	69.6	.378	.992	.572	.81	.64	.72	E. by N.	S. S. E.	S. S. E.	51.00	2.0	....	....	"	C. C. Str. 8.	Rain.
8	29.641	646	834	61.1	79.8	72.1	.480	.850	.631	.91	.85	.81	S. W.	S. S. W.	S. W.	166.80	2.0	0.503	....	Cu. Str 10.	C. Cum. 4.	Clear. Aur. Bor.
9	627	514	469	63.7	89.9	73.0	.409	.942	.624	.70	.68	.79	W. by N.	S. S. W.	W. S. W.	99.70	1.0	....	....	Clear.	Cu. Str. 2.	"
10	382	735	779	68.9	85.6	69.3	.510	.643	.485	.75	.48	.72	S. S. E.	S. W.	W.	96.30	1.0	....	....	Cirr. Str. 10.	Clear.	"
11	745	796	624	62.4	88 4	72.1	.376	.778	.496	.69	.59	.64	S. W.	S. W.	S. W.	90.20	1.5	....	....	Clear.	"	Cu. Str. 8.
12	585	714	866	68.3	81.6	57.0	.457	.738	.357	.69	.69	.78	S. W.	W.	W. by S.	280.80	1.0	....	....	Clear. Dist. thu. in ni.	C. Cum. 4.	Clear.
13	938	885	921	51.4	78.3	60.2	.252	.588	.374	.68	.62	.73	W.	S. W.	S. W.	1.00	1.0	....	....	"	Clear.	Str. 4. Aur. Bor.
14	730	667	646	56.4	75.7	64.2	.336	.484	.497	.75	.56	.88	S. W.	S. W.	S. W.	137.50	2.0	....	....	C. C. Str. 10.	Cu. Str. 10.	Rain.
15	666	645	706	48.1	73.2	59.0	.285	.624	.439	.85	.70	.88	S. W.	W. by N.	W.	295.60	2.5	0.161	....	Cirr. Str. 10.	" 4.	Cirr. Str. 10.
16	899	875	957	49.2	71.1	54.2	.272	.509	.308	.78	.68	.74	W.	W.	W.	139.90	1.0	....	....	Clear.	C. C. Str. 4.	Clear.
17	30.101	30.094	30.056	43.1	74.2	61.6	.209	.376	.406	.75	.47	.74	W. S. W.	W. S. W.	S. W.	56.40	1.5	....	....	Light frost.	Clear.	"
18	29.900	29.857	29.751	51.4	79.2	63.0	.270	.612	.278	.72	.62	.83	S. W.	S. W.	S. W.	39.60	1.5	Inapp.	....	C. C. Str. 4.	C. C. Str. 8.	Cu. Str 4. Aur. Bor.
19	797	30.000	830	61.8	78.2	64.0	.390	.626	.464	.74	.65	.77	S. W.	S. W.	S. W.	63.20	1.0	....	....	Clear.	Clear.	Clear. Aur. Bor.
20	841	29.853	928	60.4	82.2	65.1	.426	.610	.483	.82	.56	.78	S. W.	S. W.	N. by E.	84.20	1.5	....	....	"	C. C. Str. 8.	Cu. Str. 10.
21	962	860	928	51.4	71.6	64.1	.296	.365	.464	.79	.47	.77	N. E. by E.	N. E. by E.	S. by W.	126.70	2.0	0.160	....	C. C. Str. 10.	Cu. Str. 4.	Clear Solar Halo.
22	656	541	588	60.1	69.2	70.1	.487	.635	.537	.94	.90	.77	N. E. by E.	N. E. by E.	S. by W.	149.10	3.0	0.601	....	Rain.	Rain.	" Comet visible.
23	566	30.100	922	64.2	74.6	53.3	.464	.577	.251	.77	.64	.68	W.	S. W.	W. by N.	252.24	2.0	Inapp.	....	Cum. Str. 4.	Cum. Str. 10.	Clear.
24	30.140	110	30.077	43.8	74.1	54.2	.209	.396	.314	.75	.48	.86	W. by N.	S. W.	S. W.	82.40	1.5	....	....	Frost.	Clear.	"
25	29.918	29.780	29.723	47.2	77.2	70.1	.273	.689	.516	.85	.69	.70	S. W.	S. W.	S. W.	134 60	1.0	....	....	Frost.	"	Cu. Str. 10.
26	691	644	710	67.9	77.2	67.8	.516	.689	.556	.77	.69	.84	S. by W.	S. by W.	S. W.	61.20	1.5	Inapp.	....	C. C. Str. 10.	Rain.	C. C. Str. 4.
27	750	730	731	52.1	76.3	54.2	.334	.577	.308	.86	.64	.74	N. E. by E.	N. E. by E.	S. by E.	72.50	1.5	....	....	Cu. Str. 4.	Clear.	Clear.
28	604	513	446	60.2	72.1	62.2	.456	.631	.449	.88	.81	.85	S. E.	S. by E.	S. by E.	10.00	1.0	Inapp.	....	C. C. Str. 10.	Cirr. Str. 10.	Cu. Str. 4.
29	625	698	730	51.1	60.3	53.0	.296	.255	.321	.79	.49	.80	W. by N.	W. by N.	W. by N.	310.40	1.0	....	....	Clear.	" 4.	" 4. Aur. Bor.
30	30.030	30.010	971	40.1	70.0	56.2	.182	.516	.363	.73	.70	.81	W. by N.	S. W.	S. W.	140.40	1.5	....	....	Frost.	Clear.	Clear.
31	29.887	29.806	654	52.0	80.6	62.2	.315	.711	.429	.83	.68	.77	S. W.	S. W.	S. W.	155.00	1.5	....	....	Clear.	"	"

REPORT FOR THE MONTH OF SEPTEMBER, 1862.

Day of Month.	Barometer—corrected and reduced to 32° F. (English inches.)			Temperature of the Air.—F.			Tension of Aqueous Vapour.			Humidity of the Atmosphere.			Direction of Wind.			Horizontal Movement in 24 hours. In miles.	OZONE. Mean amount of	RAIN. Amount of, in inches.	SNOW. Amount of, in inches.	WEATHER, CLOUDS, REMARKS, &c., &c. [A cloudy sky is represented by 10, a cloudless one by 0.]		
	6 a. m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m.	6 a.m.	2 p. m.	10 p. m.	6 a. m.	2 p. m.	10 p. m.					6 a. m.	2. p. m.	10 p. m.
1	29.346	29.204	29.214	60.1	64.2	63.2	.487	.529	.543	.94	.89	.94	S. W.	S. W.	S. W.	201.90	3.0	0.976	....	Rain.	Rain. Dist. Thunder.	Rain.
2	347	564	797	49.1	55.2	45.2	.297	.263	.206	.85	.64	.69	S. W.	W.	W. by N.	325.58	1.5	....	....	Cu. Str. 8.	Cirr. Str. 4.	Clear. Aur. Bor. at 2 a.m.
3	892	896	30.022	40.1	66.1	54.0	.203	.438	.335	.82	.68	.80	W. by N.	W. by N.	W.	63.20	1.5	....	....	Frost.	Clear.	" Aur. Bor.
4	902	820	29.830	50.0	83.4	70.4	.290	.597	.580	.82	.53	.80	S. W.	S.	S. W.	109.40	1.0	....	....	C. C. Str. 9.	Cu. Str. 8.	"
5	821	772	840	70.2	77.2	70.1	.592	.841	.621	.83	.91	.85	S. W.	S. W.	W.	116.60	2.0	Inapp.	....	C. Cum. 4.	Rain.	"
6	811	798	890	57.1	57.7	54.0	.436	.459	.396	.94	.97	.96	N. E. by E.	N. E. by E.	N. E. by E.	237.20	3.0	1.261	....	Rain.	Rain.	Rain.
7	727	650	710	47.4	66.2	61.1	.311	.509	.449	.93	.81	.85	N. E. by E.	N. E. by E.	S. by E.	92.20	2.0	0.130	....	Cu. Str. 10.	C. C. Str. 10.	Cu. Str. 9.
8	649	534	611	69.2	81.0	63.2	.671	.751	.478	.95	.72	.83	S. E.	S. W.	W.	202.90	2.5	0.587	....	Rain.	Cu. Str. 4.	Clear.
9	937	999	30.037	58.1	72.4	56.0	.400	.631	.363	.84	.81	.81	W.	W.	S. W.	203.10	1.0	....	....	Clear.	Clear.	" Aur. Bor.
10	30.047	30.019	025	50.2	79.7	68.2	.290	.606	.577	.82	.60	.85	S. W.	S. W.	S. W.	18.60	1.0	....	....	"	"	"
11	29.984	29.904	29.869	50.1	84.7	67.2	.309	.577	.496	.85	.49	.77	S. W.	S. W.	S. by W.	7.50	1.5	....	....	"	"	"
12	747	720	816	65.1	74.1	62.1	.549	.436	.491	.89	.53	.88	S. by W.	S. by W.	N. N. E.	136.50	1.5	0.110	....	C. Cirr Str. 4.	Rain.	Cum. Str. 8.
13	904	30.014	30.134	60.4	68.4	60.0	.396	.356	.283	.76	.53	.78	N. E. by E.	N. E. by E.	N. E. by E.	249.40	1.0	....	....	Clear.	Clear.	Clear.
14	30.241	150	030	45.2	69.1	54.2	.251	.543	.335	.94	.79	.80	N. E. by E.	S. E.	S. E.	68.50	1.0	....	....	Cirr. Str. 10.	Str. 2.	"
15	29.938	29.954	29.963	54.1	64.0	53.0	.335	.497	.321	.80	.83	.80	S. W.	S W.	S. W.	0.80	2.0	0.304	....	C. C. Str. 4.	Rain.	"
16	30.050	30.000	30.004	45.0	66.1	53.0	.251	.400	.328	.84	.61	.83	S. W.	S. W.	S. W.	6.80	1.5	....	....	Clear.	Clear.	"
17	29.951	29.964	29.976	42.0	68.4	56.3	.244	.443	.391	.91	.65	.87	S. W.	S. W.	N. E. by E.	102.80	1.5	....	....	Fog.	"	"
18	704	575	700	56.7	71.3	69.1	.398	.537	.571	.90	.71	.82	S. W.	S. W.	S. W.	139.20	1.0	....	....	Cu. Str. 4.	Cu. Str. 10.	"
19	736	785	937	64.0	70.9	59.2	.490	.571	.410	.81	.84	.82	S. W.	S. W.	S. W.	60.10	1.5	Inapp.	....	C. C. Str. 8.	C. Cum. 4.	" Faint Aur. Bor.
20	970	940	816	39.1	79.4	63.0	.195	.886	.491	.82	.87	.88	S. W.	S. W.	S. W.	19.90	1.5	....	....	Clear.	Clear.	"
21	913	30.027	30.106	48.1	72.0	50.2	.285	.496	.290	.85	.64	.82	S. W.	S. W.	S. W.	24.10	1.0	....	....	"	"	"
22	30.047	29.910	29.926	42.1	78.2	62.1	.222	.671	.466	.83	.71	.85	S. by E.	S. W.	S. W.	11.10	2.0	....	....	"	"	"
23	29.870	675	680	44.4	86.2	68.4	.202	.557	.543	.74	.54	.79	S. S. W.	S. by W.	S. W.	36.90	1.5	....	....	"	"	"
24	612	739	830	54.2	65.6	45.0	.341	.542	.258	.83	.87	.88	N. W.	W.	W.	116.20	2.5	0.164	....	Rain.	Cu. Str. 4.	" Faint Aur. Bor.
25	430	789	832	44.2	67.9	56.0	.224	.431	.391	.79	.66	.87	W.	S. W.	S. W.	30.30	1.0	....	....	C. C. Str. 10.	Clear.	" " " "
26	819	797	863	45.1	73.0	60.1	.228	.476	.439	.76	.59	.88	S.	S. W.	S. W.	103.40	1.5	....	....	Clear.	"	" " " "
27	855	847	804	57.0	83.4	64.0	.413	.597	.497	.90	.53	.83	S. W.	S. W.	S. W.	148.19	1.0	....	....	"	"	" Aur. Bor.
28	805	712	741	54.1	78.6	64.2	.362	.619	.497	.87	.64	.83	S. W.	S. W.	S. W.	10.70	1.5	....	....	Cu. Str. 4.	Cirr. Str. 4.	" Faint Aur. Bor.
29	704	654	842	56.0	66.6	54.1	.398	.463	.302	.90	.71	.87	S. W.	N. E. by E.	N. E. by E.	39.30	1.5	....	....	" 4.	C. C. Str. 10.	Cu. Str. 8.
30	972	978	30.071	39.1	44.2	34.0	.261	.157	.162	.91	.55	.87	N. E. by E.	N. E. by E.	S. by E.	105.90	2.5	....	....	Cirr. Cum. 4.	" 4.	Clear.
...	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....

REMARKS FOR AUGUST, 1862.

Barometer....... Highest, the 24th day, 30·140 inches.
Lowest, the 28th day, 29.446 "
Monthly Mean, 29.792 "
Monthly Range, 0.694 "

Thermometer... Highest, the 4th day, 93°6.
Lowest, the 24th day, 34°0.
Monthly Mean, 65°61.
Monthly Range, 59°6.

G.
Lowest intensity of the Sun's rays, 105°3.
Mean point of Terrestrial radiation, 31°2.
Amount Humidity, ·727.
Rain fell Evaporation, 2.07 inches.
9 days amounting to 1.425 inches; it was raining 15 hours and 40 minutes.

Most prevalent wind, S. W.
Least prevalent wind, the N. by E.
Most windy day the 29th day, mean miles per hour, 12.92.
Least windy day the 13th day, mean miles per hour, 0.04.
Aurora Borealis visible on 6 nights.
Comet visible.
The Electrical state of the Atmosphere has been marked by Moderate Intensity.
Temperature of Thermometer in ground, 65°.0.
Solar Halo on the 21st day.
Frost on 4 mornings.

REMARKS FOR SEPTEMBER, 1862.

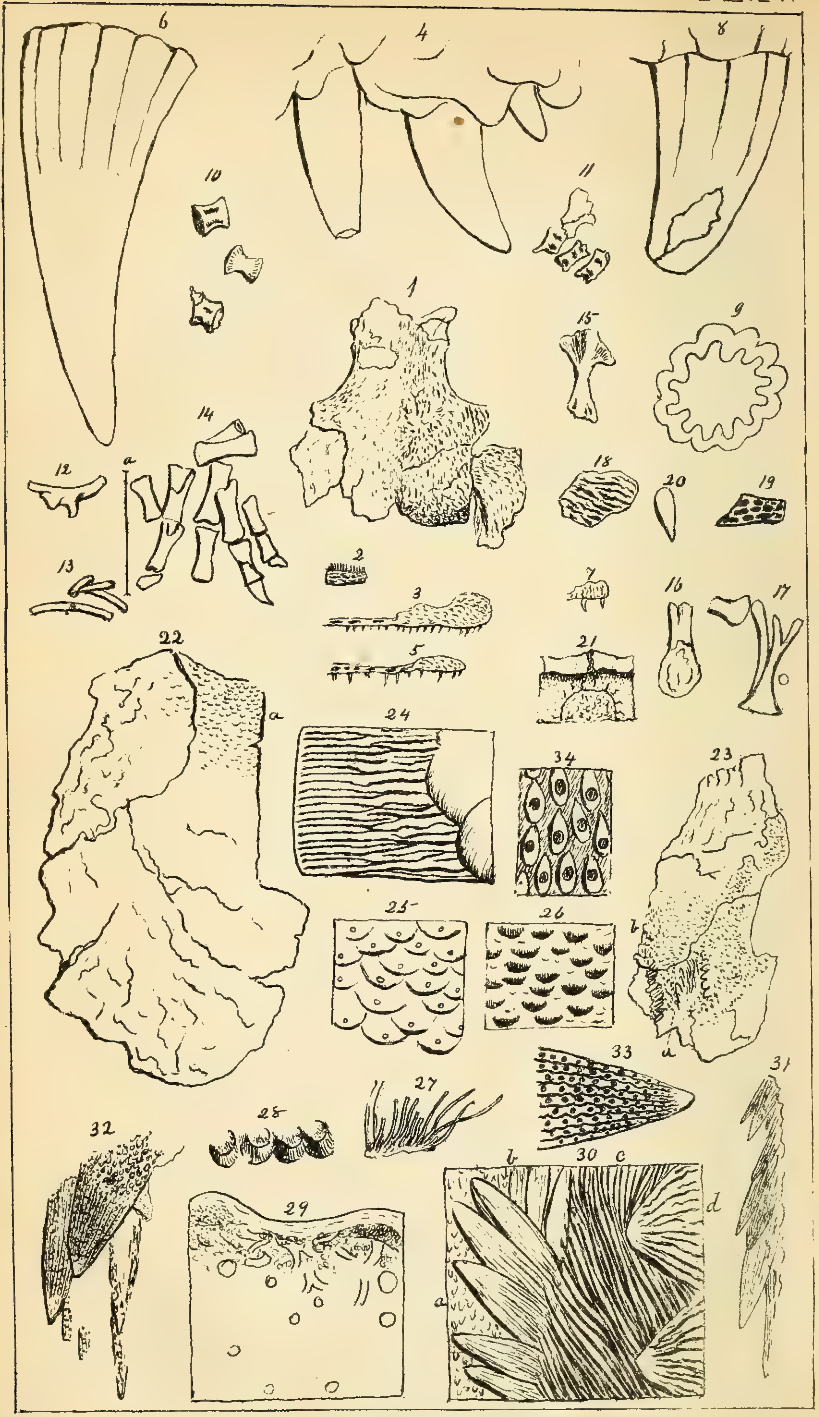
Barometer. ...... Highest, the 21st day, 30.106 inches.
Lowest, the 1st day, 29.204 "
Monthly Mean, 29.833 "
Monthly Range, 0.902 "

Thermometer. Highest, the 14th day, 84°9.
Lowest, the 3rd day, 32°2.
Monthly Mean, 59°48.
Monthly Range, 52°7.

Greatest intensity of the Sun's rays, 98°0.
Lowest point of Terrestrial radiation, 30°1.
Mean of humidity, ·791.
Amount of Evaporation, 1.86 inches.
Rain fell on 9 days, amounting to 3.532 inches; it was raining 64 hours.

Most prevalent wind, S. W.
Least prevalent wind, S.
Most windy day, the 2nd day; mean miles per hour, 13.59.
Least windy day, the 15th day. Inapp.
Aurora Borealis visible on 9 nights.
Temperature of the ground at 18 inches, 63°.2.
The Electrical state of the Atmosphere has indicated feeble intensity.

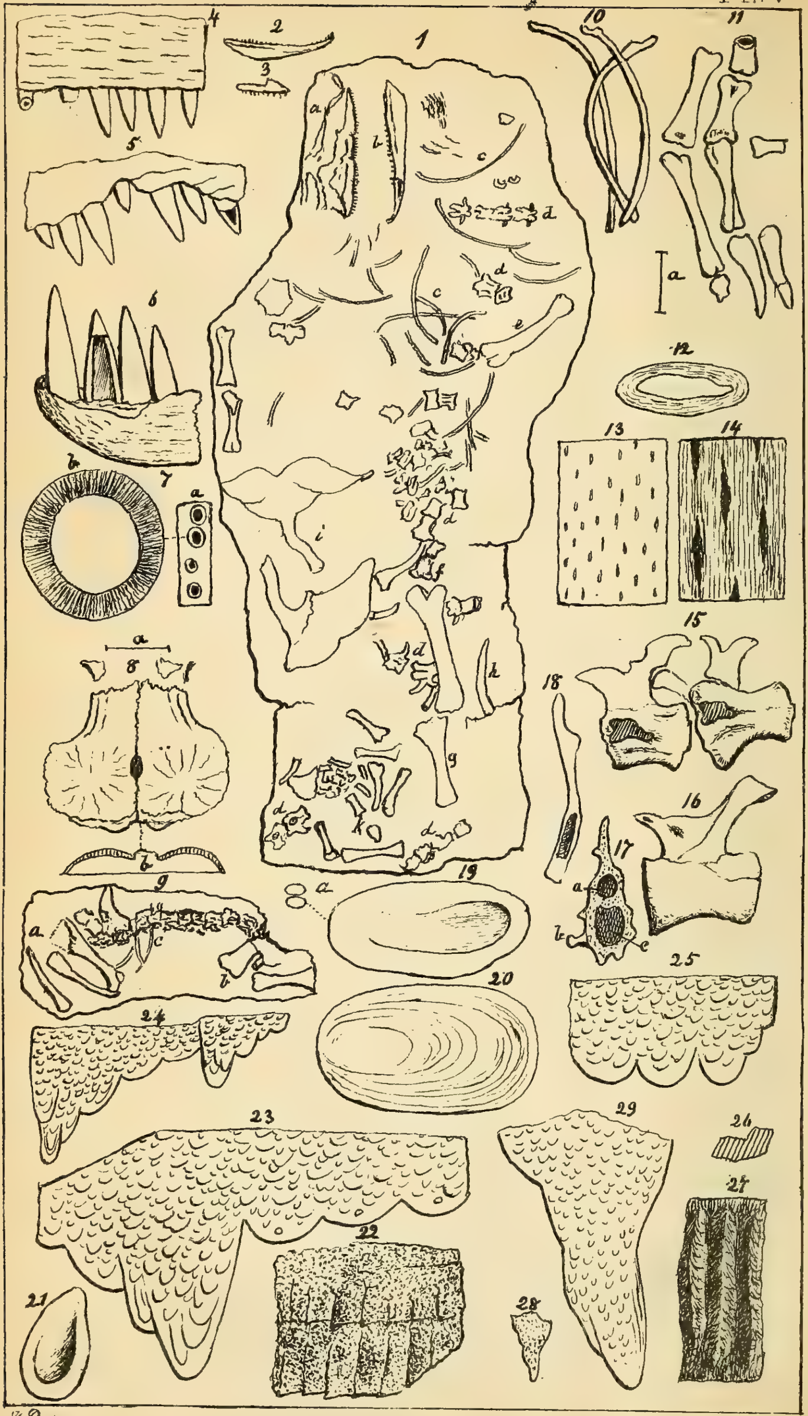
PL. IV.



JWD. Art.

DENDRERPETON OWENI. *Dawson* (Figs. 1 to 21)
Skin & Horny Scales (Figs. 22 &c.)

Pl. V



J.W.D. del.

HYLONOMUS LYELLI. *Dawson.*

THE

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Art. XIII.—*The Air-Breathers of the Coal Period in Nova Scotia;* by J. W. Dawson, LL.D., F.R.S., &c.

(*Continued from page* 92.)

V. Dendrerpeton Oweni.

Plate IV.

Among the reptilian remains found in erect trees at the South Joggins, there have occurred several portions of skeletons, which from their sculptured cranial bones, plicated teeth, and the forms of their scales and limb-bones, I have referred to the genus *Dendrerpeton*, but to individuals of much smaller size than the full-grown specimens of *D. Acadianum*. It did not occur to me to suppose that these were specifically distinct from the larger individuals, until I observed that bones of this kind, contained in the collections sent by me to the Geological Society, or represented in the figures drawn to illustrate one of my papers, were referred by Professor Owen, in his notes on these specimens and figures, in the Journal of the Geological Society, to the genus *Hylonomus*; which is quite distinct from *Dendrerpeton*, as will be explained in the sequel.

I was thus induced to re-examine all the specimens in my collection, and the result has been to establish a strong probability that there is in reality a second species of *Dendrerpeton*, smaller than *D. Acadianum*, and differing from it in several points. This species I propose to name *D. Oweni*. It differs from *D. Acadianum* in the following particulars:—(1) Its much smaller size: (2) Its long and hooked teeth; Pl. IV, Figs. 2 to 8; (it will be seen that these teeth differ very markedly in their proportions and form from those of the larger species represented in Pl. III): (3) The greater plication of the ivory in the intermaxillary teeth; Figs. 8, 9; (in *D. Acadianum* these teeth are, on the outside, simple almost to the base, and plicated on the inner side, while in this species they are plicated all around like the inner maxillary teeth): (4) The form of the skull, which has the orbits larger in proportion, and is also shorter and broader. On the other hand, when we have described the species of *Hylonomus,* it will be seen that this animal, except in size, differs from them quite as widely as does *D. Acadianum.*

The distinctness of *D. Oweni* is further confirmed by the fact that I possess small jaw bones of *Dendrerpeton*, about the size of those of this species, but having the teeth similar in form to those of the larger species; these I suppose to have belonged to young individuals.

On examining the figures, it will be seen that the bones of the skull were corrugated as in the large *Dendrerpeton*, but with a smaller pattern. The forms of the jaw-bones also, and of the vertebræ, ribs, scapular bone, bones of the limbs, and bony scales, are very similar, and indicate that in general form this creature was not far removed from its larger relative. The bones of the foot, represented in Fig. 14, especially deserve attention. This is the most perfect foot of *Dendrerpeton* hitherto found; and I have enlarged it in the figure, in order more distinctly to show its parts. It presents three long toes, with traces of a smaller one at each side, so that there were probably five in all. If these toes be compared with the footprints on the slab discovered by Dr. Harding, represented in Pl. I, Fig. 2, it will be seen that they very closely correspond, though the toes of the present species are much smaller. The footprints are precisely those which we may suppose an animal of the size of *Dendrerpeton Acadianum* would have made, if, as the bones found render in every way probable, this larger species had a foot similar to that of *D. Oweni.* I suppose, for this reason, that these footprints are really those of *Dendrerpeton Acadianum*; and that this species continued to exist from the time of the lower coal measures, to the period when those higher beds of the series, in which its bones are found at the Joggins, were deposited.

The present species must have lived in the same places with its larger relative; but may have differed somewhat in its habits.

Its longer and sharper teeth may have been better suited for devouring worms, larvæ or soft-skinned fishes, while those of the larger *Dendrerpeton* were better adapted to deal with the mailed ganoids of the period, or with those smaller reptiles which were more or less protected with bony or horny scales.

VI. REMAINS OF SKIN AND HORNY SCALES.

Plate I, Fig. 5; Plate IV, Figs. 22 to 34, and Plate V, Figs. 22 to 29.

In one of my earliest explorations of the reptile-bearing stumps of the Joggins, I observed on some of the surfaces, patches of a shining black substance, which on minute examination proved to be the remains of cuticle, with horny scales and other appendages. The fragments were preserved; but I found it impossible to determine with certainty to which of the species whose bones occur with them they belonged, or even to ascertain the precise relations of the several fragments to each other. I therefore merely mentioned them in general terms, and stated my belief that they may have belonged to the species of *Hylonomus*.* More recently other specimens have been obtained, and I have undertaken the detailed examination of the whole. I shall now endeavour to describe the principal or most continuous fragments, and afterward to consider the probabilities of their having belonged to certain of the reptiles entombed with them. I do this here, rather than under the titles of these several animals, on account of the uncertainty which still rests on the assignment of certain portions of this cuticle to the species in question, and which renders it more convenient to consider these peculiar remains in one place, and to compare the different portions with each other.

(1) One of my specimens is a flattened portion of cuticle $2\frac{1}{4}$ inches in length. The greater part of the surface is smooth and shining to the naked eye, and under the microscope shows only a minute granulation. A limited portion of the upper, and I suppose, anterior part is covered with imbricated scales, which must have been membranous or horny, and generally have a small spot or pore near the outer margin, some having in addition smaller scales or points on their surfaces, (Pl. IV, Figs. 22 and 25). In contact with the upper part of this specimen there were many fragments of the skull of *Dendrerpeton Oweni*.

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* Journal of Geological Society, Vol. XVI.

(2) Another portion of cuticle, similarly marked, appears to preserve the form of the posterior part of the body and tail of the animal, and also a mark representing the point of attachment of the hind leg; near to which, and along the dorsal ridge, is a portion of the skin covered with much smaller scales. It is represented in Pl. I, fig. 5. This was found in close proximity to a mass of bones of *Dendrerpeton Oweni*, mingled with some of *Hylonomus Lyelli*.

(3) A third and still larger surface of integument with similar markings, has upon it a number of vertebræ and detached bones of the small reptile *Hylonomus Wymani*, to be described in the sequel; for which species however it would be much too large a covering.

(4) Another well preserved fragment, less than two inches in length, exhibits very different markings. It is nearly covered with very small imbricated scales, thicker than those on the specimens previously described. On either side of what seems to have been the middle line of the back, there is a series of pointed flat horny processes, which probably formed a double spinous crest. Without these there are tufts of strong bristles, and exteriorly to these last are rows of flat, thick, horny plates, transversely wrinkled. Near to these was a row of conical truncated tubercles. Sections of these appendages show them to have been horny and attached to the cuticle. None of them have bony structure. Figs. 23, 26, 27, 28, 29, 30, Pl. IV, represent this portion of cuticle, with magnified views of its markings, and of the structure of one of the thicker scales. Fig. 26 shows a portion of the ordinary scaly skin magnified and viewed by transmitted light. Fig. 27 exhibits a few of the bristle-like appendages from the point marked *a* in fig. 23. Fig. 28 shows four of the bluntly-conical points seen in a portion of skin a little beyond the margin of the fragment in fig. 23, but evidently belonging to it. Fig. 24 is an enlarged representation of one of the flat horny scales from the point *b* in fig. 23; and fig. 29 is a magnified section of a portion of the same scale, showing a compact translucent brown substance with round canals, and near the margin, a portion much more abundantly supplied with these apparently vascular canals, while without this part there is a thin layer of more dense material. Fig. 30 shows a portion of the surface of fig. 23, more highly magnified, and displaying at *a* ordinary scales, at *b* horny pointed organs, at *c* bristly appendages, and at *d* large

plates. The whole of these parts, though displaced by the flattening and wrinkling of the skin, are in good preservation, and show their characters in great perfection under the microscope. They are all black and shining as if carved in jet.

(5) Near this last portion of cuticle, and possibly belonging to it, are pointed and probably membranous appendages, marked on each side with rows of scales not overlapping, and each with a pore in its centre. The manner in which these appendages are bent and wrinkled, shows that they must have been soft, except at the tips, which seem to have been hard and horny, and they are arranged in series, as if originally placed along the sides of the neck or abdomen, or both. These appendages are represented in Pl. IV, figs. 31 and 32. A magnified representation of the point of one of them is given in fig. 33, and a small portion, still more highly magnified, in fig. 34. The use of these appendages it is not easy to conjecture. They remind us of the gular pouches of iguana, and of the lateral expansions of some geckos and of the *Draco volans.* Possibly they formed lateral parachutes, aiding the animal in moving over soft mud, or perhaps in leaping or swimming.

(6) Some other fragments appear to have belonged to a different species from either of the foregoing, and are represented in Pl. V. The best preserved specimen (Fig. 22), which is about one inch in length and half an inch in breadth, is covered with very small imbricated scales. It is crossed by six or seven obscure ridges, which both at the bottom and along a mesial line, projected into points covered with larger scales. A row of large scales with round pores, connects these along the lower side (Figs. 23 and 24.) If, as seems probable, this fragment belonged to the side of the trunk or tail, it would perhaps indicate a division of the sub-cutaneous muscles into an upper and lower band, as in the newts. A separate fragment, with transverse horny ridges (Figs. 26 and 27), and another with a longer lobe similar in structure to those above mentioned (Figs. 28 and 29), may perhaps be referred to the same animal. A larger patch of skin presents similar imbricated scales, but without a mesial line, and with an edging of larger scales (Fig. 25).

Six species of reptiles have left their bones in the repositories containing these remnants of cuticle. Of these, *Dendrerpeton Acadianum* was an animal of too great size to have been clothed with integument of this character and of such dimensions. *Hylo-*

nomus aciedentatus, described in Section VIII, and *Hylerpeton Dawsoni*, Section X, are each represented by only a single specimen, and these did not occur in proximity to any of the portions of cuticle, except that the appendages in Pl. IV, fig. 32, were found near a specimen of the former. Of the three remaining species, *Dendrerpeton Oweni*, from its size, the number of specimens found, and the juxtaposition of their bones to the fragments of cuticle, appears to have the best claim to the integument included under Nos. 1, 2, and 3 ; and in this case, while the creature had its throat, and perhaps its abdomen, armed with bony scales, its upper parts and tail, as well as its limbs, had a uniform covering of small thin imbricated horny scales, in the manner of many modern reptiles.

If the remaining portions of integument, Nos. 4 and 5, as would seem likely, belonged to two species, both of smaller dimensions, there would seem little reason to doubt that these were *Hylonomus Lyelli* (Section VII) and *H. Wymani* (Section IX). In this case, both of these species must have possessed a highly ornate covering of horny scales and appendages, comparable with that of any of the modern lizards, while there seems good reason to believe, as stated in a previous paper, that they were in part protected by bony scales somewhat like those of *Dendrerpeton*. These points, however, we shall consider more in detail under the sections which refer to the species of *Hylonomus*.

Before leaving these curious specimens of ancient skin, the most ancient I suppose known to exist, it is of interest to observe that the thicker portions, when broken across, have the aspect of jet, or of pure shining coal, and that thin slices, under the microscope, have the same rich brown colour with that material, though rather more translucent. When burned, fragments of the substance give a strong flame, and a bituminous and ammoniacal odour. We have thus an example of the production of coal from animal membrane, no doubt gelatinous and horny in the first instance, but which has proved itself capable of the same chemical changes that have been experienced by the vegetable matter buried with it. In order that this substance should be preserved in this way, it would be necessary that it should either be kept dry and hard, or that it should be immediately buried in matter impervious to air, and kept moist. The latter conditions are the more probable. The preservative qualities of the peaty vegetable matter imbedded with it must also be considered; and it is possible that these hollow stumps partly filled with fragments of Sigillaria bark, may have formed natural tan-pits, in which animal membranes would be preserved in a manner impossible in ordinary sediments. If this were the case, we may yet find an entire reptile, preserved as a flattened mummy, in one of these strange repositories.

Explanation of Plate IV.

Dendrerpeton Oweni, and Dermal Appendages.

Fig. 1.—Skull.
" 2.—Portion of mandible.
" 3.—Maxillary bone, with outer teeth.
" 4.—Teeth of same enlarged.
" 5.—Maxillary bone, with inner teeth.
" 6.—Tooth of same enlarged.
" 7.—Intermaxillary.
" 8.—Tooth of same enlarged.
" 9.—Section of same enlarged.
" 10 and 11.—Vertebræ.
" 12.—Portion of pelvis.
" 13.—Fragments of ribs.
" 14.—Bones of foot enlarged, (*a*) natural size.
" 15.—Scapular bone.
" 16.—Humerus.
" 17.—Bones of hind leg.
" 18 and 19.—Sculpturing of cranial bones, enlarged.
" 20.—Bony scale.
" 21.—Socket of inner tooth enlarged.
" 22 and 25.—Integument of *Dendrerpeton Oweni*, with imbricated scales.
" 23.—Integument of *Hylonomus Lyelli.*
" 24, 26, 27, 28, 30.—Scales and appendages of the same enlarged.
" 29.—Section of scale represented in Fig. 24.
" 31.—Angular pendants or processes of *H. Lyelli.*
" 32.—The same of *H. aciedentatus.*
" 33 and 34.—Portions of the same enlarged.

VII. Hylonomus Lyelli.

Plate V.

In the original reptiliferous tree, discovered by Sir C. Lyell and the writer, at the Joggins, in 1851, there were, beside the bones of *Dendrerpeton Acadianum*, some small elongated vertebræ, evidently of a different species. These were first detected by Prof. Wyman, in his examination of these specimens, and were figured, but not named, in the notice of the specimens in the Journal of the Geological Society, Vol. IX. In a subsequent visit to the Joggins, I obtained from another erect stump many additional remains of these smaller reptiles, and, on careful comparison of the specimens, was induced to refer them to three species, all apparently generically allied. I proposed for them the generic name *Hylonomus*, "forest-dweller." They were described in the proceedings of the Geological Society for 1859, with illustrations of the teeth and other characteristic parts.* The smaller species first described I named *H. Wymani*; the next in size, that to which this article refers, and which was represented by a larger number of specimens, I adopted as the type of the genus, and dedicated to Sir Charles Lyell. The third and largest, represented only by a few fragments of a single skeleton, was named *H. aciedentatus.*

Hylonomus Lyelli was an animal of small size. Its skull is about an inch in length, and its whole body, even if, as was likely, furnished with a tail, could not have been more than six or seven inches long. No complete example of its skull has been found. The bones appear to have been thin and easily separable; and even when they remain together, are so much crushed as to render the shape of the skull not easily discernible. They are smooth on the outer surface to the naked eye; and under a lens show only delicate uneven striæ and minute dots. They are more dense and hard than those of *Dendrerpeton*, and the bone-cells are more elongated in form. The bones of the snout would seem to have been somewhat elongated and narrow. A specimen in my possession shows the parietal and occipital bones, or the greater part of them, united and retaining their form. We learn from them that the brain-case was rounded, and that there was a parietal foramen. There would seem also to have been two occipital condyles; (see plate V, fig. 8.). Several well preserved specimens of the maxillary and mandibular bones have been obtained. They are smooth, or nearly so, like those of the skull, and are furnished with numerous sharp, conical, teeth, anchylosed to the jaw, in a partial groove formed by the outer ridge of the bone. In the anterior part of the lower jaw there is a group of teeth larger than the others. The intermaxillary bone has not been observed. (Figs. 1, 2, 3, 4, 5, 6.) The total number of teeth in each ramus of the lower jaw was about forty, and the number in each maxillary bone about thirty. The teeth are perfectly simple, hollow within, and with very fine radiating tubes of ivory. (Fig. 7, *a* and *b*.) The vertebræ have the bodies cylindrical or hour-glass shaped, covered with a thin, hard, bony plate, and having within a cavity of the form of two cones, attached by the apices. This cavity was completely surrounded by bone, as it is filled with stained calc-spar in the same manner as the cavities of the limb bones. It was probably occupied by cartilage. The vertebræ were apparently bi-concave. The neural spines are short and broad, with zygapophyses, and are not separable from the bodies, the neural arches being perfectly anchylosed to the bodies of the vertebræ. There are, on the dorsal vertebræ, strong diapophyses or lateral spines, to which the ribs were articulated. (Figs. 15, 16, 17.) The ribs are long, curved, and at the proximal end have a shoulder and neck. (Figs. 1, 10, 18.) They are hollow, with thin hard bony walls. The anterior limb, judging from the fragments procured, seems to have been slender, with long toes, four or possibly five in number. A humerus is seen in fig. 1, and bones of the toes magnified in fig. 11. The posterior limb was longer and stronger, and attached to a pelvis so large and broad as to give the impression that the creature enlarged considerably in size toward the posterior extremity of the body, and that it may have been in the habit of sitting erect. The thigh bone is well formed, with a distinct head and trochanter, and the lower extremity flattened and moulded into two articulating surfaces for the tibia and fibula, the fragments of which show that they were much shorter. The toes of the hind feet have been seen only in detached joints. They seem to have been thicker than those of the fore foot. Detached vertebræ, which seem to be caudal, have been found, but the length of the tail is unknown. The limb bones are usually somewhat crushed and flattened, especially at their articular extremities, and this seems to have led to the error of supposing that this flattened form was their normal condition; there can be no doubt, however, that it is merely an effect of pressure. The limb bones present in cross section a wall of dense bone with elongated bone-cells, surrounding a cavity now filled with brown calc-spar, and originally occupied with cartilage or marrow. (Figs. 12, 13, 14.) Nothing is more remarkable in the skeleton of this creature than the contrast between the perfect and beautiful forms of its bones, and their imperfectly ossified condition, a circumstance which raises the question whether these specimens may not represent the young of some reptile of larger size.

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* Journal of Geological Society, Vol. XVI.

The dermal covering of this animal is represented in part by oval bony scales, which are so constantly associated with its bones that I can have no doubt that they belonged to it, being, perhaps, the clothing of its lower or abdominal parts; while above, it was probably clad in the beautiful scaly covering described in the last section. The bony scales are represented magnified in Plate V. figs. 19. 20, and 21. It will be seen that they differ in form from those of *Dendrerpeton;* they are also much thicker. On the inner side they are concave, with a curved ledge or thickened border at one edge. On the outer side they present concentric lines of growth.

The only specimens which afford much information as to the general form of *Hylonomus Lyelli* are those represented in Plate V, figs. 1 and 9. The first is the original specimen, from which I described the species in the paper already referred to. The bones, being small and of dark colour, are not very conspicuous, and many of them are broken, but many are beautifully perfect; and even those which are removed have left very distinct moulds of their form in the fine-grained matrix. In the figure I have carefully traced their outlines in their natural position, with the exception of the maxillary bone and mandible, which are removed from their place in the matrix, to bring the whole into a more compact form. The specimen also shows, in addition to the bones delineated, many fragments of the skull and scapular bones, crushed in such a manner that their forms cannot be distinguished. The specimen shows remains of thirty vertebræ, of which four appear to belong to the neck, and the rest are probably nearly all dorsal and lumbar. Three of the most perfect are represented enlarged, in figs. 15 and 16. Of about twenty ribs, more or less complete fragments remain. The fore limb is represented only by the impression of a humerus, (*e*), but other bones which may have belonged to it are scattered elsewhere on the stone. The pelvis, (*i*) is nearly entire, though crushed and flattened. One thigh bone remains tolerably perfect, and beside it lie the tibia and a part of the fibula, with several bones of the foot. The dimensions of these parts are as follows:—

Length of maxillary	0.7 inch.
" mandible	0.7 "
" longest rib, (chord)	0.6 "
" humerus	0.5 "

Length of femur	0.7 inch.
" tibia	0.45 "
" principal bone of pelvis	0.7 "

The other specimen above referred to, (Fig. 9.) shows the bones of the trunk, and part of those of the hind and fore limb of a small individual, nearly in their natural position. This specimen I have very recently obtained, in breaking open a mass of matrix in which I did not suspect its existence. It shows the humerus and radius and ulna in a tolerable state of preservation, with a fragment of the scapula. About thirteen dorsal and lumbar vertebræ can be made out, nearly in their natural position ; and there are remains of five of the ribs. The hind limb is represented by fragments of the femur, tibia, and fibula. I believe that the maxillary represented in fig. 3, though now in a detached piece of stone, belonged to this skeleton.

While referring to these, my most perfect specimens, I think it proper to quote my original description of the species, based on the first of them, and published in 1859 ; as the subject has since been unfortunately obscured by inaccurate descriptions, consequent on the mixture of specimens and drawings, sent by me to London for further examination. I quote from the journal of the Geological Society, Vol. XVI.

"HYLONOMUS, gen. nov."

" The other reptilian remains represent three species belonging to a generic form, which, so far as I am aware, has not been previously observed, and for which, in allusion to its forest habitat, I propose the above name. As its typical species I shall describe that which I would name *Hylonomus Lyelli*. Its cranial bones are thin and smooth ; the condyle I have not been able to observe, but there is a parietal foramen, and the parietal bones are arched in such a manner as to indicate a rounded rather than flattened skull, and a somewhat capacious brain-case. Its teeth are numerous (about twenty-six in each maxillary bone), elongated, conical, closely set in a single series, in a furrow, protected externally by an elevated alveolar ridge. In the intermaxillaries and extremities of the mandibles the teeth are larger than elsewhere. Fig. 14, (Fig. 5, Plate V. of this paper) represents a portion of the teeth of the maxillary bone as exposed by the fracture of the outer ridge. The vertebræ are imperfectly preserved, but appear to have been ossified, bi-concave, and with well-developed spinous processes. The ribs are long and curved; and there are traces of numerous accessory pieces which have been attached to their extremities. The pelvis is of large size and remarkable form; the ilium long and expanded below; the ischium greatly expanded; the pubis expanded and triangular where it joins the ischium, and round and arched toward the symphysis. The femur is thick and nearly straight, the tibia short and stout, the fibula slender, the phalanges broad. The hind limb thus largely developed must have been capable of supporting the whole weight of the body in standing or leaping. The anterior extremities appear to have been comparatively slender, with thin and long fingers. A few scattered vertebræ lying posteriorly to the pelvis, may perhaps be remains of a tail. There was a dermal covering of small ovate bony scales, of which, however, only a few scattered specimens remain. This species is evidently quite remote from the ganocephalous and labyrinthodont types of batrachians, and in many respects approaches to lacertians. It may perhaps be allied to the *Telerpeton* of Elgin, but does not appear to resemble any reptile hitherto found in the coal-formation."

It is evident, from the remains thus described, that we have in *Hylonomus Lyelli* an animal of lacertian form, with large and stout hind limbs, and somewhat smaller fore limbs, capable of walking and running on land; and though its vertebræ were imperfectly ossified externally, yet the outer walls were sufficiently strong, and their articulation sufficiently firm, to have enabled the creature to erect itself on its hind limbs, or to leap. They were certainly proportionally larger and much more firmly knit than those of *Dendrerpeton.* Further, the ribs were long and much curved, and imply a respiration of a higher character than that of modern batrachians, and consequently a more highly vitalized muscular system. If to these structural points we add the somewhat rounded skull, indicating a large brain, we have before us a creature which, however puzzling in its affinities when anatomically considered, is clearly not to be ranked as low in the scale of creation as modern tailed batrachians, or even as the frogs and toads. We must add to these also, as important points of difference, the bony scales with which it was armed below, and the ornate apparatus of horny appendages, with which it was clad above. These last, as described in the last section, and illustrated in Plate IV., shew that this little animal was not a squalid, slimy dweller in mud, like *Menobranchus* and its allies, but rather a beautiful and sprightly tenant of the coal-formation thickets, vying in brilliancy, and perhaps in colouring, with the insects which it pursued and devoured. Remains of as many as eight or ten individuals have been obtained from three erect sigillariæ, indicating that these creatures were quite abundant, as well as active and terrestrial in their mode of life.

With respect to the affinities of this species, I think it is abundantly manifest that it presents no close relationship with any reptile hitherto discovered in the Carboniferous system. The only indications of which I am aware of animals of this age, likely to be of similar type, are certain vertebræ discovered by Mr. Wheatley and Dr Newberry, in the coal formation of Ohio, and described, but not named, by Prof. Wyman, in Silliman's Journal, Vol. XXV, in connection with the singular bratrachian named by him *Raniceps Lyclli ;* which, in its broad frog-like head and want of ribs, differs materially from the creature now under examination. It is scarcely necessary to say that the characters above described, and illustrated by the figures in Plate V, entirely remove this animal from *Archegosaurus* and *Labyrinthodon*, as well as from all the other creatures associated with them in the orders *Ganocephala* and *Labyrinthodontia* of Owen. Equal difficulties attend the attempt to place it in any other group of recent or extinct batrachians or proper reptiles. The structures of the skull, and of some points in the vertebræ, certainly resemble those of batrachians; but on the other hand, the well-developed ribs, evidently adapted to enlarge the chest in respiration, the broad pelvis, and the cutaneous covering, are unexampled in modern batrachians, and assimilate the creature to the true lizards. I have already, in my original description above quoted, expressed my belief that *Hylonomus* may have had lacertian affinities, but I do not desire to speak positively in this matter; and shall content myself with stating the following alternatives as to the probable relations of these animals. (1)They may have been true reptiles of low type, and with batrachian tendencies. (2) They may have been representatives of a new family of batrachians, exhibiting in some points lacertian affinities. (3) They may have been the young of some larger reptile, too large and vigorous to be entrapped in the pit-falls presented by the hollow Sigillaria stumps, and in its adult state losing the batrachian peculiarities apparent in the young. Whichever of these views we may adopt, the fact remains, that in the structure of this curious little creature we have peculiarities both batrachian and lacertian, in so far as our experience of modern animals is concerned. It would however accord with observed facts in relation to other groups of extinct animals, that the primitive batrachians of the coal period should embrace in their structures, points in after times restricted to the true reptiles. On the other hand, it would equally accord with such facts that the first-born of lacertians should lean toward a lower type, by which they may have been preceded. My present impression is, that they may constitute a separate family or order, to which I would give the name of MICROSAURIA, and which may be regarded as allied, on the one hand, to certain of the humbler lizards, as the GECKO or AGAMA, and, on the other, to the tailed batrachians.

It is likely that *Hylonomus Lyelli* was less aquatic in its habits than *Dendrerpeton.* Its food consisted, apparently, of insects and similar creatures. The teeth would indicate this, and near its bones there are portions of coprolite, containing remains of insects and myriapods. It probably occasionally fell a prey to *Dendrerpeton*, as bones, which may have belonged either to young individuals of this species or to its smaller congener *H. Wymani*, are found in larger coprolites, which may be referred with probability to *Dendrerpeton Acadianum.*

EXPLANATION OF PLATE V.

Hylonomus Lyelli, and Dermal appendages.

Fig. 1.—Remains of a skeleton of a large individual of *Hylonomus Lyelli;* (*a*) Maxillary; (*b*) Mandible; (*c*) Ribs; (*d*) Vertebræ; (*e*) Humerus; (*f*) Femur; (*g*) Tibia; (*h*) Fibula, (*i*) Pelvis; (*k*) Foot.
" 2.—Right Mandible.
" 3.—Maxillary.
" 4, 5.—Portions of Maxillary, magnified.
" 6.—Extremity of Mandible, magnified.
" 7.—Sections of teeth; (*a*) magnified, (*b*) highly magnified.
" 8.—Portion of cranium, magnified; (*a*) natural size, (*b*) transverse section.
" 9.—Skeleton of the trunk of a small individual of *H. Lyelli;* (*a*) Fore limb, (*b*) Hind limb, (*c*) Ribs.
" 10.—Ribs from the slab, Fig. 1, magnified.
" 11.—Fore foot, magnified; (*a*) natural size.
" 12.—Cross section of flattened femur, magnified.
" 13, 14.—Portions of the bone of the same, more highly magnified.

Fig. 15.—Pair of Vertebræ (dorsal), magnified.
" 16.—Vertebra magnified.
" 17.—Vertebra broken across and magnified, showing (*a*) neural arch, (*b*) diapophysis, and (*c*) central cavity.
" 18.—Head of a rib, magnified.
" 19, 20,21.—Bony scales, magnified, (*a*) natural size.
" 22.—Portion of cuticle, probably of *Hylonomus Wymani.*
" 23, 24.—Parts of the same magnified.
" 25.—Lower margin of another portion of cuticle, magnified.
" 26, 27.—Ridged horny scale, natural size and magnified.
" 28, 29.—Cutaneous lobe, natural size and magnified.

(*To be continued.*)

ART. XIV.—*On the Superficial Geology of the Gaspé Peninsula*; by ROBERT BELL, C. E.; of the Geol. Survey of Canada.

(*Read before the Natural History Society.*)

The Gaspé peninsula embraces the region lying to the eastward of a line drawn across the country from the head of the Bay of Chaleur to about Matan on the St. Lawrence, and measures 140 miles in length by 70 in breadth.

The superficial accumulations of this district differ in their general character from those of the country to the west. One of the most remarkable points of difference is the absence of foreign boulders in Gaspé. On arriving in Gaspé Bay last spring, my attention was at once arrested by the contrast presented to many other parts of the country by the general scarcity of boulders of any kind in the fields, notwithstanding the hilly nature of the ground. On examination it was found that the loose masses were chiefly confined to the summits and more abrupt slopes of the hills, and farther, that they always belonged to rocks which existed *in situ* close by. During the whole summer, which was spent mostly in the interior of the County of Gaspé, my attention was directed to the inquiry; but I failed to discover a single stone which had not been derived from the rocks of the country, until I visited Cape Gaspé and Point Peter, where boulders of Laurentian gneiss were found in abundance on the sea beach. While the erratic masses of the interior are probably due to ancient glacial action, the presence of the Laurentian boulders on the beach, on the northern sides of Cape Gaspé and Point Peter, is no doubt owing to recent icebergs. The proof of this lies in the fact of their occurrence only on the beach, and that at points projecting into the open sea frequented by drifting ice, while they appear to be altogether absent from the shores of the bay between these points. Gaspé Bay remains covered with fixed ice till late in the spring, and thus icebergs from the north are prevented from entering it. This want of far-transported boulders over such a large area, is a fact of great importance; for when we find loose fragments of useful minerals in this region we may be sure their source is not far off.

In the Gaspé country the geologist is not aided by artificial excavations; but the superficial strata may be studied in the natural sections afforded by land slides, and by the wearing away of the banks along the rivers and coast. Excepting the patches close to the shore, there is an entire absence of the flat-lying clay and regularly bedded sand so widely spread in the St. Lawrence valley to the westward. Along the river valleys, great accumulations of loose gravel are spread over the unmodified drift, or boulder formation, and on the lower levels the gravel is covered with loam or silt. In passing through the intervals, the streams in many places eat away their banks, first on one side and then at the next bend below, on the opposite side, depositing the material on the banks alternately opposite, and in this way the minor courses of a river are changed in a few years. At one time a small portion of the York River, at high water, flowed through a narrow channel, north of the main one, for a distance of about two miles, just before reaching the head of tide water. About twenty years ago, some obstructions were removed from this channel to allow timber to pass down it; and since that time it has become gradually enlarged, until now the whole river passes through it, except during freshets, when a part is forced through the old channel.

A vast amount of material must be transported every year from the land into the sea by the action of these streams. The greater portion of it is carried out from the shore by the currents and deposited on the bottom of the sea. Alluvial islands and mud flats are formed at the mouths of some of the rivers which enter the sea in sheltered situations. The most conspicuous of these are found in Gaspé Bay, at the mouths of the Dartmouth and York Rivers, where the meadow islands, comprising hundreds of acres, furnish pasture and hay for the horses and cattle of the settlers in the neighbourhood. Natural dykes are thrown up along the borders of these islands, and upon them long rows of trees and bushes venture out beyond the outline of the woods upon the upper islands.

Along the rivers, the silt is from one to six feet and even more in thickness, and is frequently found to consist of very thin layers, separated by films of vegetable matter, probably marking the annual increase. Near the sea level, the silt is generally more than six feet in depth, and is much mixed with prostrate timber, often in such quantities as to suggest the idea that they are jammed accumulations of drift-wood which have been gradually buried beneath the soil.

Besides underlying the river intervals, the unmodified drift frequently occupies the smaller valleys and ravines, to a considerable depth. It consists generally of a stiff and sticky mixture of coarse sandy clay with gravel and boulders. The majority of the boulders are small, and many of them are longitudinally grooved and striated. It is impossible to say what thickness this boulder formation may attain, but it was seen exposed in many places to a depth of at least 100 feet. So far as the evidence afforded by the materials themselves is concerned, it would thus appear to be of local glacial origin. Some of the banks occur in such situations as to suggest the idea of their having been terminal moraines of the glaciers which once ran down the valleys. No ice grooves have hitherto been observed upon the solid rocks, probably because these are seldom or never uncovered in situations where their occurence might be looked for. Grooves were found on the rocks at the head of the fall on the Dartmouth, and a fall at the mouth of its first large tributary from the north. These were no doubt produced by stones borne by the ice and drift timber which are swept rapidly down with the freshets in spring. These current scratches are quite short, and made upon an uneven surface; while true glacial furrows are continuous, and always occur on a smoothed or planed base. Some years ago, the tributary just referred to, cut off a narrow neck of land which separated it from the river for several hundred yards, so that it now enters it in a direct course, at right angles to that of the river. At every spring freshet, since this change took place, it has precipitated a large quantity of shingle over the ledge at its mouth, into the bed of the river, and in this way a bank has been formed opposite to the fall which is already as wide as the former channel of the river, and is every year increasing in extent, and turning the main stream farther out of its original course.

The small amount of debris usually found about the cliffs would seem to indicate that the country had existed in its present condition for a comparatively short period; but on the other hand, there are facts which shew that the present state of things has continued for a very great length of time. The principal of these are the accumulation of sand bars and points along the coast, and the wearing of the solid rocks in the channels of the rivers. About ten miles from its mouth, the Darmouth river crosses the Gaspé limestone in a gorge varying from 100 to 200 feet deep, cut through the whole formation, which is more than 2,000 feet thick, and tilted up at an angle of 45 degrees. At the Mountain Portage, on the Magdalen, the river flows in a deep and narrow ravine cut in the shale for a distance of a mile below the high fall. It is not asserted that these ravines have been excavated altogether by the rivers themselves, but they appear to have deepened them considerably. The second stretch of the York River cuts the Gaspé limestones and sandstones almost at right angles to their strike, and often flows for a considerable distance between perpendicular walls of sandstone, from twenty to eighty feet in height. The river itself appeared to have been the principal agent in wearing these channels. In some places large masses of the sandstone, which are known to have fallen from the cliffs within a recent period, are diminishing rapidly every year by the action of the ice and water, while the accumulations of the fragments, which are seen at every bend, when the water is low, afford striking evidence of the great wearing and transporting power of this rapid stream. Where the sandstone beds lie almost horizontally the river has in some cases cut for itself a very deep and narrow channel in the bottom of the main gorge. Two of these narrows, as they are termed, are only about one foot wide, and yet the whole volume of the river, at its ordinary height, passes through these confined spaces. It was necessary of course, to carry our canoes at these places, and although the extremely narrow portions were only a few yards in length, the channels leading into them were in both cases so crooked as scarcely to allow the canoes to turn between the walls. The sandstone beds in this part of the river are almost everywhere riddled with pot-holes. Many of them are very deep, and by their constant enlargement they sometimes meet and merge into one another. In this way one of the narrow places just described has been partly formed. One of the pot-holes measured thirteen feet in depth and eleven feet in diameter, and many others close by were nearly as large. The surface of the rock at the top of one of the cliffs, about twenty feet above the present river bed, was observed to be worn smooth by the action of water, and covered by several feet of gravel.

Behind St. John's Bay on the west coast of Newfoundland Mr. James Richardson observed a set of ancient sea margins, seven in number, rising above one another at intervals varying from 50 to 150 feet. The lowest is 500, and the highest 1225 feet, above the sea, and each is marked by a horizontal belt of boulders and pebbles of Potsdam sandstone, arranged by the waves of the sea when it stood at these levels. At Blanc-Sablon Bay, on the Labrador side of the Straits of Belleisle, as many as fourteen distinct terraces with beach gravel on each, occur between 47 and 357 feet above high-water mark. There is thus sufficient evidence of a great depression and subsequent elevation of the land in this region, while in Gaspé a bank of stratified sand and gravel, eighty feet high, which occurs on the Magdalen River at an elevation estimated at 1600 feet above the sea, and similar deposits at many intermediate levels, indicate that a gradual rise of equal amount has taken place in the peninsula, but possibly at a different period. I am not aware that far transported boulders have been noticed anywhere on the high lands between Gaspé and the meridian of Quebec, but must leave this uncertainty, and also the reason of their apparent absence in Gaspé, to be solved by future research, and proceed to describe the modified drift of the district.

The narrow border of clay land extending almost continuously from Quebec along the south side of the St. Lawrence, terminates a few miles below Matan; and to the east of this locality only a few small patches of clay occur on the north coast. The largest of these is at the mouth of the Magdalen River, and comprises about 1000 acres on the west side of Magdalen Bay. It is probably fit for the manufacture of bricks, and holds marine shells. No stratified clay whatever appears to exist on the eastern coast, but in the southern part, it occurs along the Bay of Chaleur for some distance on each side of the mouth of the Great Cascapedia River. In this clay, Sir William Logan found shells of *Mya* and *Saxicava* in a great number of beds lying above one another, to the height of seventeen feet over high-water mark, in the position which they occupied when in life. Each bed is separated from the one below it by a thin layer of sand, which also fills the tubular openings through which the inhabitants of the shells once communicated with the surface. At L'Anse au Gascon, near Port Daniel, *Mya arenaria*, *M. truncata*, *Cardium Grœnlandicum*, and

Tellina proxima were found in sand at about fifteen feet above high-water mark. The gravel beds which have been already mentioned as existing along the river valleys, are sometimes arranged in terraces. One of the most striking examples of this, is met with six miles up the York River. Here a regular terrace about thirty-five feet high comes to the north side, and runs almost straight for about three miles, cutting off the bends of the river. About twenty-five miles up the same stream, and more than 400 feet above the sea, the gravel is almost destitute of vegetation, and is worn into a number of terraces and mounds. Terraces were observed not far from the shore at Grand Pabos and on the west side of Mal Bay. Three of the most conspicuous at the last mentioned locality were estimated at eight, fifteen and fifty feet above the sea. On the south side, of the northwest arm of Gaspé Bay, an ancient beach, 154 feet above the water, is marked by a sudden step along a hill-side, and traces of other beaches are found at lower levels. On the north side of the peninsula a terrace is met with in many localities at an average height of fifty feet. At the mouth of the Matan River, the upper six feet of this terrace is of fine sand resting upon bluish clay; at their junction are found *Natica clausa*, *Mya arenaria*, *Tellina Grœnlandica*, *Mytilus edulis*, and *Mesodesma Jauresii*, together with *Balanus crenatus.* West of Matan a well marked terrace of the same height occurs one mile below the Metis River. Eight miles up this river, *Balanus Hameri*, *Natica clausa* and *Saxicava rugosa* are found at the height of 245 feet above the sea; and two miles west of the mouth of the same river, *Saxicava rugosa* and *Mya arenaria* occur in sand at the height of 130 feet.

An upheaval of the land appears to be going on, along the south side of the lower St. Lawrence. At Rivière du Loup, *Tellina Grœnlandica*, and a large variety of *Mya arenaria* are imbedded in great numbers, in the sand and disintegrated shale of raised beaches along both sides of a rocky ridge running eastward from the Government Quay, and varying from about five to about fifteen feet above the highest tides. To the east of Rivière du Loup, narrow terraces or raised beaches are met with in many localities, favorable to their preservation, along the coast as far as Cape Gaspé. They are found at numerous heights from the present sea level to fifteen feet above it. A terrace about five feet above the high-tide mark, and averaging 100 yards in breadth, extends from Rimouski to Whale Cape,with the exception of some interruptions caused by steep and rocky portions of the coast. It is composed of fragments of shells, and the ruins of the rocks which rise in the banks behind it, and forms an excellent road-bed, as well as a productive soil. The shells of these terraces belong to the same species as those now living on the shore, and among them the *Mesodesma*, which is not found in the post-pliocene deposits about Quebec or Montreal, is particularly abundant, immense numbers of these shells sometimes occurring in groups without any intermixture of sand or gravel. Large bones of whales were observed in several places between Metis and Matan, partially imbedded in the five-feet terrace. At Ste. Anne des Monts five or six distinct terraces of sand and gravel rise one above another to a height of about twenty-five feet over the sea. They all abound in shells, generally much broken and worn, belonging to the common littoral species. The formation of sand points, and of long sand beaches, closing up bays, and forming lagoons in numerous places on the east and south coasts, would also indicate that a gradual elevation of the land is now going on. The principal of these are, Peninsula Point and Sandy Beach, which, stretching from the opposite sides of Gaspé Bay, leave but a narrow channel between their extremities; the beach running across from Cape Haldimand to Douglastown, forming Douglastown Lagoon; the narrow beach nearly five miles long separating Mal Bay from the Barachois; the beaches of Grand Pabos and Port Daniel Lagoons; Pespebiac Point; and the beach forming the lagoon at the mouth of the Wagamet, or Bonaventure River. These beaches are above the influence of the tides, and, in places, support a growth of spruce trees. Peninsula Point is nearly covered by a spruce grove. In the northwest arm of Gaspé Bay several small partially wooded sand points have been formed at the foot of the high rocky banks; and these, like the two large points, are found by the settlers who live on the top of the cliffs, to be very convenient for landing places, and by the whalers for their sheds. Some of the points were observed to be thrown up into a series of small parallel ridges. Barriers of sand and gravel are thrown across several small coves or recesses between rocky points near Grand Pabos; and in this way a number of ponds are produced which being above the influence of the tide, are quite fresh, and to them, the sea-birds resort every day to drink. These facts appear to prove that the elevation of the country along the south side of the lower St. Lawrence, is still in progress. I might however add that I was informed by an old resident, that on some of the flats between Rivière du Loup and Rivière Ouelle large drifted logs lie rotting in places now rarely reached by the highest tides, and even then they are covered by only a few inches of water—quite insufficient to float such large timber. On the north coast of Gaspé I observed the remains of a very old wreck lying among spruce bushes above high-water mark, and at the time supposed it to be an evidence of elevation. I am inclined to regard it as doubtful, however since reading the accounts in the newspapers of the effects of the great gale and unprecedentedly high tide which recently visited these shores, sweeping away storehouses and boats supposed to be altogether beyond the influence of the sea.

The gradual subsidence of the Atlantic coast of the United States, appears to be proved beyond a doubt. In the Geological Journal for 1861, Dr. Gesner states that between New England and Newfoundland, the coast of the British provinces is rising in some places, while it is being submerged in others. Perhaps the most remarkable proof of subsidence is the sunken forests in Minas Bay, fully described by Dr. Dawson in his *Acadian Geology*. The elevation of Gaspé, now going on, is probably a continuation of the same movement which caused the whole peninsula to rise above the sea, and which appears to be connected with the other undulatory movements extending along the coast of the whole continent. It is worthy of remark, in connection with this subject that in Ohio and Upper Canada, a very gentle inclination appears to have been detected in some of the ancient water margins. On the Labrador coast, besides the evidence of recent upheaval afforded by the raised sand and limestone-gravel plains, and the worn pillars of Mingan, Sir Charles Lyell states that some of the rocks above the sea level at this locality are perforated by the burrows of the *Saxicava* in such a good state of preservation as to show that they have not been exposed to the weather for a very great length of time. In addition to these facts, the occurrence of whales' bones, covered by moss and lying among the bushes above the influence of the tide, in both Labrador and Newfoundland, affords geological evidence of elevation, while a gradual rise of that island above the sea appears to have been observed by the inhabitants, as is shewn by the following extract from the *Newfoundland Times* of October, 1847 :—

" It is a fact worthy of notice that the whole of the land in and about the neighbourhood of Conception Bay—very probably the whole island—is rising out of the ocean, at a rate which promises at no very distant day, materially to affect, if not to render useless, many of the best harbors we have on the coast. At Port de Grave a series of observations have been made, which undeniably prove the rapid displacement of the sea level in the vicinity. Several large flat rocks, over which schooners might pass some thirty or forty years ago with the greatest facility, are now approaching the surface, the water being scarcely navigable for a skiff."

Montreal, February 2nd, 1863.

ART. XV.—*On the Rocks of the Quebec Group at Point Lévis;* by SIR WILLIAM LOGAN, F.R.S.; Director of the Geological Survey of Canada; in a letter addressed to M. Barrande.

MONTREAL, 15th MARCH, 1863.

MY DEAR MR. BARRANDE,—Mr. Jules Marcou has addressed to you a letter dated the 2nd August last, on the Taconic rocks of Vermont and Canada, in which he says, on page 10, " I was able this " year to follow out and trace every bed and layer on the whole " contour of Point Lévis, from the Grand Trunk Terminus to Indian Cove; and as Point Lévis is a point of land surrounded " by high cliffs, I feel satisfied that there is no repetition of beds, " and no synclinal axis; and that the few foldings of the strata " at Ferry's cliff are mere accident, confined to a distance of a few " feet, and are without any effect upon the whole mass of strata " but are what we call in French *structure ployée* (contorted " strata)." On page 14 he says: " Fearing that my first unsuccessful attempt last year to understand the explanation of Messrs. " Logan and Billings might be my own fault, I tried very hard " this year again, when at Point Lévis, but with no better success " and I left the Point fully convinced that the fossils described by " Mr. Billings, and the so-called outcrops, A^2, A^3, A^4, &c., of " Mr. Logan, were collected and observed in a very careless way, " without regard to stratigraphy, by irresponsible collectors, or " by unskilful practical geologists."

I have neither time nor inclination for controversial geology. I have never criticised any of Mr. Marcou's remarks on rocks in Canada, or out of it, nor have I suggested any such criticisms to others; but a charge of carelessness on the part of public officers in the discharge of their duties appears to me, on the present occasion, to require a few words of reply, lest you and others might suppose the accusation to have some foundation. It is due to Mr. Marcou to give him credit for the very great care he claims, as I am persuaded he would not have ventured so unreserved and condemnatory a contradiction of what has been stated on the part of the Survey, without having exhausted all his skill on his own investigation. The only critical remark therefore left for me to make, is that this distinguished stratigraphist has been very unfortunate; and that having missed the main feature of the conspicuously marked structure he so carefully searched for, it is not surprising that he should find a difficulty in understanding a statement connected with it.

In 1854 and 1856, a considerable time was expended by Mr. Richardson, one of my assistants, and myself, in ascertaining by measurement the position and extent of all the exposures of the limestone conglomerates which characterize Point Lévis. The result of this work was exhibited by me to Mr. Marcou, at the office of the Survey, in 1861, on an unpublished manuscript map, on a scale of six inches to one mile, showing nearly all the known exposures of rocks of the Quebec group for about twenty miles below, twenty miles above, and nearly twenty miles to the south-eastward of Quebec. This map represents an area of 800 square miles, on which all the exposures are laid down by admeasurements, comprising the work of one member of the Survey for two seasons, and of another for one season. The measurements at Point Lévis I have recently re-protracted on the same scale, with a view of completely separating what is exposed to view, from what is inferred; and a plan reduced from this to one half, by photography, accompanies the present communication. The topographical as well as the geological features are delineated from the measurements of the Survey.

On this plan, the heavy black bands represent the known exposures of the limestone conglomerates; the dotted lines between different exposures represent their supposed connection. Some of the geographical undulations are shown by what I have designated the Coast Ridge, and the North, Middle and South Ridges. The main feature of the Coast Ridge is a thick band of limestone conglomerate extending in a hill and precipice, which overlook the beach from Patton's wharf to the neighborhood of the Lower Ferry; beyond which it gives place to the cliff immediately behind the houses near the Lower, Middle and Upper Ferries. The

North Ridge is a hill which rises up from and runs parallel with the road passing in front of the Temperance Monument or Cross; and attains its greatest height in a band of limestone conglomerate about 300 yards southeastward. The part of this ridge nearest the road probably constitutes Mr. Marcou's Cross Hill. The Middle Ridge is, I presume, Mr. Marcou's Parochial Hill. It includes Guay's quarry, or the Redoute, and crossing the St. Joseph Church road (Route de l'Eglise), extends for about a mile to the southwestward, with a somewhat broad depression southward from the Burying-ground. Where Mr. Marcou's Middle Hill may be situated, I am not quite sure, but suppose it to be the upper part of my North Ridge, as the extension of this seems to be the only hill between the Temperance Monument and Guay's quarry. The South Ridge crosses the St. Joseph Church road about half a mile to the southeastward of the Middle Ridge.

The limestone conglomerates, as you are probably aware, consist of beds of yellow-weathering magnesian limestone, in which, as a base, are imbedded masses of pure compact limestone, of colors varying from yellowish-white, through gray and brownish, to nearly black. These masses are generally of a sub-spherical or sub-elliptical form, looking like boulders, and many of them may probably be such; but beds of a limestone almost precisely similar to them in character appear occasionally to run in an irregular manner in the conglomerate bands, presenting the aspect of original sediments. The yellow-weathering matrix is often arenaceous, the white silicious grains sometimes attaining a quarter of an inch in diameter. The bands of conglomerate are separated rom one another by greenish and blackish slates, which in many places, are interstratified with strong yellow-weathering gray and black calcareo-magnesian slates, and occasionally with yellow-weathering sandstones. In a few places red slates are intermingled with the others.

South-eastward from the St. Lawrence, the limestone conglomerates of Point Lévis are distributed over a breadth of more than two miles. In the North Ridge there are four bands, numbered 1, 2, 3, 4, on the map; on which is represented, in addition, a long lenticular bed (4^a) subordinate to 4, but separated from it by slate. The lenticular bed is composed of brown-weathering magnesian limestone, but appears to contain few or no enclosed masses of the pure limestone. The bands 3 and 4 are, respectively, A^2 and A^3 of a former description. You will perceive that northeastwardly they converge a little; and at the time of that description, it was not determined whether they were to be considered two distinct beds, or one a repetition of the other. They are now taken to be two distinct beds. Followed northeastwardly, they appear to be dislocated by a fault near the St. Joseph Church road; but beyond this they are easily traceable around the extremity of a trough, with a deep channel worn between them in the slate. After passing the axis of the synclinal, the band 4 comes to the limestone of Guay's quarry, which is nothing more than a large lenticular mass of pure limestone, subordinate to the band. Southwestward of the quarry, both bands are seen again crossing the St. Joseph Church road, and again coming against the transverse fault. This fault appears to show an upthrow on its southwest side; since on that side the opposite outcrops of the trough are thrown towards the centre.

Continuing to trace the outcrops on the southern side of the trough, that of band 4 gradually thins, and disappears at P, in less than a furlong; while that of band 3 becomes more conspicuous, and shows a great development as it folds over an anticlinal axis just eastward of the eastern boundary of the fief St. Anne. From this it returns towards the Church road, but becomes concealed about fifty yards before reaching it, after again shewing the effect of the fault, in a much smaller horizontal displacement than before. On the northeast side of the anticlinal axis, on both sides of the fault, the dip is to the southeastward, and is therefore overturned; but from the character of the displacement it is evident that beneath the surface, on the northeast side of the fault, the inversion must be compensated for by a change to the northwest in the slope.

A little above the outcrop of band 4, at P, there occurs a layer of sandstone, which is traceable on the fief Ste. Anne over the anticlinal axis; and a sandstone approaches the outcrop of band 3 at A¹. In the description of 1860, this was supposed to show that possibly the stratigraphical place of the band 4 might gradually approach the band 3, and finally merge into it; but finding farther on, along the outcrops, an exposure of conglomerate at *z*, which will answer for band 4, it is now conceived that there may be two layers of sandstone, one above, and the other below the stratigraphical place of band 4; and though this band thins to nothing at P, it may commence again in its relative place farther on.

From the neighborhood of the Temperance Monument the outcrop of band 2 is traceable northeastward, running not quite parallel with 3, to the fault, and thence across the St. Joseph

Church road to the main road. It traverses this obliquely, a little beyond the church, and its turn upon the synclinal axis is seen on the north side of the road, about 400 yards beyond. In the limestone of Guay's quarry there is a small notch-like turn, which serves to augment somewhat its apparent volume; a corresponding twist is more conspicuous in the outcrop of band 3, and in band 2 it assumes a still further prominence at *y*. These successive forms indicate a plait in the stratification, commencing at the quarry, and rapidly augmenting northeastwardly in the space of 350 yards. The importance of its effect on the distribution of the strata would, at this rate of increase, soon become considerable, and it serves to show some of the complications of the neighborhood.

Without going into detail, it is evident from the map that the Middle Ridge is an anticlinal form, and that the South Ridge is another. On this, the exposures of the bands 2 and 3 conspicuously mark the turn on the axis, as they do in the synclinal between the ridges. It will be perceived that between the synclinal and anticlinal axes, the outcrop of band 2 is represented as showing a very sharp twist. The evidence of this is not quite satisfactory, and the apparent arrangement may possibly be due only to a swelling in the volume of the band, with parts obscured by drift.

The Temperance Monument stands on band 1, with which are associated some layers of sandstone. This band is easily traced to the northeastward, across the fief Ste. Anne; but between that and the fault, it becomes broken down and obscured, and it will require farther investigation. Nothing like it, nor indeed any conglomerate band has been yet observed following, in its relative place, the sinuosities of band 2, where the strata are affected by the synclinals and anticlinals that have been described. Eastward of the fault, and northward of band 2, there is an exposure of conglomerate close upon the southeast side of the main road, the bearing of which would carry it under the church of St. Joseph; and two years ago it was observed in an excavation for the foundation of a house on the northwest side of the road, close by the church. In the strike of these exposures, about 400 yards beyond the church, there is a band of conglomerate, which continues in the same strike for about a hundred yards. This strike would carry the band away from those of the North Ridge, and gradually bring it towards those of the Coast Ridge; and it appears probable that the bands of the Coast Ridge may be only a repetition of some of those of the North Ridge. The main band of the Coast Ridge is associated with several beds of sandstone; and from its great breadth it may possibly be capable of division into more than one mass of conglomerate. To the southwestward of the extreme point to which this band has been traced, there occurs in the cliff, to the southeast of the Lower Ferry, the band A; one of those referred to in the description of 1860. Its exact relation to the other bands has not yet been satisfactorily determined.

Southward of A^3 you will remark A^4, and you will perceive that these two bands somewhat converge to the southwest, in which direction they are not traceable for over a quarter of a mile. At the time of the previous description, it was left undecided whether these were to be considered distinct bands, or a repetition of one another. They are now assumed to be distinct. On the Middle Ridge, the band 4, at P, is followed by B^1; which is a band of slate with nodules of limestone. On the North Ridge its place would be between A^3 and A^4. It would therefore be band 5, and A^4 would be band 6. The bands 7, 8, and 9 succeed on the north side of the Middle Ridge, the band 9 being B^2 of the former description; like B^1, it is composed of slate studded with nodules of limestone. This band appears to have a considerable development southwestwardly, in a long shallow trough-like form, extending to the Grande Côte road. From this, its outcrop returns on the south side of the Middle Ridge anticlinal, and points to B^3; which however differs from it in character, having a base of magnesian limestone instead of slate. What is seen of the band B^3 is broken into three portions by transverse faults. It is evidently on the south side of the Middle Ridge anticlinal, and may correspond with band 8, but this has not yet been satisfactorily made out; nor has it yet been found possible to arrange the complicated exposures to the southeast of it, on the South Ridge.

On the southwest boundary of the fief Ste. Anne, near the quarry there indicated, the beds appear to be dislocated on the north side of the Middle Ridge anticlinal, by faults, which do not affect the outcrops on the south side. These faults may be small breaks accompanying twists in the strata, the connecting parts of which may be concealed by drift; but it would require additional facts to make their arrangements certain. Though the number of bands is assumed to be nine, some of them may be repetitions through the effect of plaits suddenly starting up, like that at *y*, or through undetected faults running with the stratification. The distribution of the outcrops in the southwest part of the South Ridge shows the very complicated character of the disturbances, and is a warning against over-confidence in respect to minute details. In regard to the main features of the structure however, there appears to be no doubt; namely that the Middle and South Ridges are two well marked anticlinals, and that a synclinal, not less so, runs between the Middle and North Ridges, repeating the whole mass of strata.

From the foregoing explanation you will be able to understand how the fossils enumerated in the description of 1860 are related to the conglomerate bands, as represented on the map. The whole of these fossils were collected by the officers of the Survey, who are all perfectly aware of the importance of observing the exact stratigraphical place of the organic remains, and always most carefully do so. The collectors were Messrs. Billings, Richardson, Bell, and myself; and from the statements made to me by my colleagues and assistants, I am quite prepared to assert that the specimens referred to B^3, B^2, B^1, A, A^1, and A^3, are from the bands marked on the map by those letters. With the exception of a single specimen of the pygidium of *Bathyurus Saffordi*, obtained by Mr. Sterry Hunt from the band 4 (A^3), where it crosses the more northern synclinal axis near the Redoute; the band A^2 afforded to my late regretted and talented young scientific friend, Mr. John Head, and myself, the first collection of fossils obtained by the Survey at Point Lévis. These were taken from the whitish limestone masses associated with the bed, where it crosses the fief Ste. Anne, and the opinion in regard to them expressed by Mr. Billings, induced me to instruct Mr. Bell to make a farther collection on the same band. In addition to the fossils collected by Mr. Head and myself from the band, there are some by Mr. Richardson, and others by Mr. Bell, all from the fixed rock; but in Mr. Bell's collection there are, in addition, those from the limestones designated by Mr. Billings as Nos. 1 and 3. These limestones were not, like the rest, firmly attached to the band, and as they have been by Mr. Marcou designated as two loose boulders, lying on the superficial soil, while he carries them away from their true site, and approximates their position to the lime-kiln of the Redoute, in order to affiliate them to that mass, it will be necessary for me to describe their mode of occurrence.

On the fief Ste. Anne, the band 3 (A^2) dips to the southeast at a high angle. It is from about twenty to twenty-five feet thick, and in its calcareo-magnesian base it holds a great many masses of yellowish-white limestone, in which fossils are apparent, and somewhat abundant. It is underlaid by slates; and in some parts a sudden step to the underlying slates occurs at its northern edge. At the foot of this step, Mr. Bell observed in one place a mass of gray-weathering yellowish-white limestone protruding for a few inches through the soil. This mass, when excavated from its position, proved to be about a foot in diameter, and very fossiliferous. Persuaded that it had fallen from the conglomerate band, he tried farther on in the strike, and found another; and finally, in the distance of about fifty feet along the strike, he obtained five masses, each as heavy as would require a strong man to lift; and twelve smaller masses, each of about twenty pounds weight and upwards. They were all rich in fossils. Some of these gave to Mr. Billings his limestone No. 1, and others that of No. 3. All of these masses, some of which were sharply angular, rested on the slate, just at the base of the conglomerate band; and with the exception of the small portion of the first one, were wholly covered by the soil, one of them to a thickness of a foot; requiring, before it could be extracted by aid of pick, shovel, and crow-bar, a hole to be made of two feet deep. It appears to me much more probable that these masses should have fallen from the conglomerate band which they touched, than that they should have been transported nearly half a mile from the Redoute, and all laid at the foot of the conglomerate band A^2, in a row in its strike. It is by no means supposed that the stock of these masses was exhausted by Mr. Bell; more may probably be obtained in the strike, and I am persuaded, that if the adjacent parts of the conglomerate band were laid bare, similar masses would be found imbedded in it.

Mr. Marcou states that the limestones Nos. 1 and 3, without doubt come from the Redoute; and that in respect to No. 1, so rich in trilobites, he could almost point out the exact spot from which it came. Soon after the first discovery of fossils at Point Lévis, I spent a good deal of time in endeavouring to obtain specimens from Guay's quarry, but with very indifferent success. Fragments of trilobites were observed, but the only recognizable species obtained was *Menocephalus globosus*. Perceiving that Mr. Marcou had been so fortunate as to meet with upwards of nine species of trilobites in the locality, I last season renewed my attempt; and with Mr. Billings, made a diligent search of the rock, but with no better luck than had attended my previous researches; *Menocephalus globosus* being again the only speeics procured. Mr. Marcou states that the stratification is indistinct, and that in consequence of the hardness of the stone, it is difficult to obtain specimens. This perfectly accords with what we observed; but not with the characters of the limestones Nos. 1 and 3; which are not very hard, and in which the fossils occur in layers, marking well the stratification. The limestones split with moderate facility in the direction of those layers, and give considerable planes of surface, with fossils starting prominently up from them. I presume therefore that the beds at the Redoute, with which Mr. Marcou compares the limestones No. 1 and 3, are some which he has not yet desribed, and with which we can make no comparison, as we have not been so fortunate as to find them.

Since 1860. Mr. Devine and Mr. Cayley, both of the Crown Lands Department, have obtained several species at Point Lévis. The latter gentleman discovered *Amphion Cayleyi*, (Billings) in band 3, (A^2) on the North Ridge; and Mr. Devine, on the same ridge, has procured *Bathyurus Saffordi* from band 2, *Menocephalus globosus*, and *Cheirurus Eryx* from band 3 (A^2); and from band 4 (A^3) *Bathyurus Saffordi*, *B. Cordai*, and *B. bituberculatus*. But from this band he has made a very important addition to the fauna of Point Lévis, in a perfect specimen of what Mr. Billings agrees with him in considering an *Olenus*, or a closely allied genus. This was obtained on the North Ridge, just east of the fief St. Anne, in a mass of drab-colored limestone; which Mr. Devine thinks is a part of the solid band, although he has not yet tested the matter sufficiently to be positive. The same part of this band here holds *Obolella*, *Orthis Evadne*, *Camerella calcifera*, *Pleurotomaria*, *Ecculiomphalus Canadensis*, *Orthoceras*, *Agnostus Americanus*, *A. Canadensis*, *A. Orion*, *Arionellus subclavatus*, *Bathyurus capax*, *B. quadratus*, *B. Saffordi*, *Cheirurus Eryx*, *C. Apollo*, *Dikelocephalus magnificus*, *D. megalops*, *D. planifrons*, *D. Oweni*, *Menocephalus Sedgwickii*, and *M. Salteri*. In this collection, the species of *Pleurotomaria*, *Ecculiomphalus*, and *Chierurus* do not occur in the same hand-specimens of rock with the others. *Bathyurus Saffordi* is in the same specimen with *Menocephalus Salteri*. On the Middle Ridge he has obtained *Menocephalus globosus* from band 4, at the Redoute. Mr. Billings has obtained in band 2, on the North Ridge, *Bathyurus quadratus*; on the Middle Ridge, in band 6, on the north side of the anticlinal, *Leptœna decipiens*; and the same species in band 7, on the same side of the anticlinal; while band 7, on the south side of the anticlinal, has yielded him a *Pleurotomaria*, allied to *P. Laurentina*, *Orthoceras, n. s.*, *Illænus*———, and *Asaphus*———. In a band of conglomerate forming two successive mounds at the water's edge, northwest of the Coast

Ridge, and running parallel with it, he has met at D, with a new species of *Dikelocephalus*

To make the distribution of the fossils, which we in Canada (including Mr. Devine and Mr. Cayley) have obtained at Point Lévis, more clearly understood, a catalogue of them has been prepared, with the specific names of those which have been described, and a separate column for each of the bands, and made a part of the present communication. In this catalogue no certain stratigraphical place is assigned to the bands D, G, and A, in relation to the others; which, from 1 to 9, are supposed to be in ascending order. With the exception of those otherwise marked, all the determined species have been described by Mr. Billings.

Mr. Marcou, it appears to me, has gone somewhat out of his way to insinuate a discourtesy towards you on the part of the Canadian Survey, in that we have, as he says, distributed fossils of the Quebec group, in England, to more favoured geologists than yourself. Mr. Marcou could not have stated this from his own knowledge, as it is not consistent with fact. The truth of the matter is precisely the reverse of this. We long ago did ourselves the pleasure of transmitting to you a small collection of the principal species; while we have presented none to any other of our geological friends in Europe. On this side of the Atlantic we have exchanged a few specimens with Col. Jewett, of the New York State Museum, for New York species, of which we stood greatly in want; and we are just now about to make a small exchange with Mr. A. H. Worthen, State geologist of Illinois, for species from several of the Western States, of which we have long been anxious to possess authentic specimens. Mr. Marcou seems especially aggrieved that he did not obtain a pygidium of *Dikelocephalus magnificus*, asked for, as he states, in your name. This was during my absence in England, at the International Exhibition. Mr. Billings cannot call to his recollection that the application was made in your name. Such an application would have afforded him the opportunity of informing Mr. Marcou, that you were probably already supplied, in the collection sent; but it would not have altered the propriety of what, in conformity with his duty, he found himself under the necessity of replying; namely that he was not authorized to distribute the specimens of the Provincial Collection.

I am, my dear Mr. Barrande,

Yours very truly,

W. E. LOGAN.

M. Joachim Barrande,
Rue Mézière No. 6, Paris,

CATALOGUE OF FOSSILS FROM THE QUEBEC GROUP, COLLECTED AT POINT LÉVIS.

	D	G	A	1	2	3	4	5	6	7	8	9
Tetradium ?		*										
Graptolithus, several sub-genera (Hall)		*					*					
Lingula Mantelli						*	*					
“ Irene		*										
“ Quebecensis			*									
Obolella Ida						*	*					
“ desiderata			*									
Acrotreta n. s.						*						
Leptæna decipiens								*	*	*	*	*
“ sordida								*				
“ undescribed 1.								*				
“ “ 2.						*						
“ “ 3.							*					
Strophomena, undescribed			*									
Orthis gemmicula								*				
“ Tritonia								*				
“ orthambonites (Pander)								*				
“ Euryone								*				
“ Electra								*				
“ Hippolyte								*				
“ Evadne								*				
“ Mycale								*				
“ Eudocia								*				
“ Quebecensis			*									
“ undescribed 1.						*						
“ “ 2.							*					
“ “ 3.							*					
“ “ 4.												*
Camerella calcifera						*	*					
Stricklandia ? Arachne								*				
“ Arethusa								*				
Cyrtodonta ? undescribed								*				
Ecculiomphalus Canadensis							*	*				
“ intortus							*					
Pleurotomaria vagrans							*					
“ Postumia							*					
“ Quebecensis							*					
“ undescribed 1.							*	*				
“ “ 2.							*					
“ “ 3.											*	
“ “ 4.											*	
Murchisonia, undescribed, 1.							*					
“ “ 2.							*					
“ “ 3.							*					
“ “ 4.											*	
Helicotoma perstriata							*					
Ophileta uniangulata (Hall)							*					
“ undescribed, 1.							*					
“ “ 2.							*					
Maclurea Atlantica											*	
Holopea dilucula (Hall)							*					
“ undescribed							*					
Metoptoma Melissa							*					
“ Hyrie							*					
“ Orphyne							*					
“ Venillia						*	*					
“ anomala							*					

	D	G	A	1	2	3	4	5	6	7	8	9
Metoptoma Augusta							*					
“ superba							*					
Orthoceras Autolycus							*					
“ undescribed 1.							*					
“ “ 2.							*					
“ “ 3.							*					
“ “ 4.							*					
“ “ 5.							*					
“ “ 6.												*
Cyrtoceras Metellus							*					
“ Dictys							*					
“ Alethes							*					
“ Mercurius							*					*
“ Syphax												
“ undescribed							*					
Nautilus “												*
Agnostus Americanus						*	*					
“ Orion						*	*					
Agnostus Canadensis						*	*					
Amphion Cayleyi						*	*					
Ampyx, undescribed							*					
Arionellus cylindricus						*						
“ subclavatus						*						
Asaphus Illænoides						*						
“ goniurus						*	*					
Bathyurus capax						*						
“ dubius						*						
“ bituberculatus						*						
“ armatus						*	*					
“ Saffordi							*					
“ oblongus							*					
“ Cordai							*					
“ quadratus					*		*					
Cheirurus Apollo							*					
“ Eryx							*					
Conocephalites Zenkeri						*	*					
Dikelocephalus magnificus						*	*					
“ planifrons						*	*					
“ Oweni						*						
“ Belli						*	*					
“ megalops						*						
“ cristatus						*						
“ undescribed	*											
“ (Olenus) Logani (Devine)							*					
Endymion Meeki											*	
Holometopus Angelini											*	
Illænus, undescribed											*	
Leperditia											*	
Menocephalus globosus						*	*					
“ Sedgwicki						*	*					
“ Salteri (Devine)							*					
Nileus, undescribed							*				*	
Shumardia granulosa				*								

Art. XVI.—*On the Chemical and Mineralogical Relations of Metamorphic Rocks*;* by T. Sterry Hunt, M.A., F.R.S.; of the Geological Survey of Canada.

At a time not very remote in the history of geology, when all crystalline stratified rocks were included under the common designation of primitive, and were supposed to belong to a period anterior to the fossiliferous formations, the lithologist confined his studies to descriptions of the various species of rocks, without reference to their stratigraphical or geological distribution. But with the progress of geological science, a new problem is presented to his investigation. While palæontology has shown that the fossils of each formation furnish a guide to its age and stratigraphical position, it has been found that sedimentary strata of all ages, up to the tertiary inclusive, may undergo such changes as to obliterate the direct evidences of organic life; and to give to the sediments the mineralogical characters once assigned to primitive rocks. The question here arises, whether in the absence of organic remains, or of stratigraphical evidence, there exists any means of determining, even approximately, the geological age of a given series of crystalline stratified rocks;—in other words, whether the chemical conditions which have presided over the formation of sedimentary rocks, have so far varied in the course of ages, as to impress upon these rocks marked chemical and mineralogical differences. In the case of unaltered sediments it would be difficult to arrive at any solution of this question without greatly multiplied analyses; but in the same rocks, when altered, the crystalline minerals which are formed, being definite in their composition, and varying with the chemical constitution of the sediments, may perhaps to a certain extent, become to the geologist what organic remains are in the unaltered rocks, a guide to the geological age and succession.

It was while engaged in the investigation of metamorphic rocks of various ages in North America, that this problem suggested itself; and I have endeavoured from chemical considerations, conjoined with multiplied observations, to attempt its solution. In the *American Journal of Science* for 1858, and in the *Quarterly Journal of the Geological Society of London* for 1859 (p. 488), will be found the germs of the ideas on this subject, which I shall endeavour to explain in the present paper. It cannot be doubted that in the earlier periods of the world's history, chemical forces of certain kinds were much more active than at the present day. Thus the decomposition of earthy and alkaline silicates under the combined influences of water and carbonic acid, would be greater when this acid was more abundant in the atmosphere, and when the temperature was probably higher. The larger amounts of alkaline and earthy carbonates then carried to the sea from the decomposition of these silicates, would furnish a greater amount of calcareous matter to the sediments; and the chemical effects of vegetation, both on the soil and on the other atmosphere, must have been greater during the Carboniferous period, for example, than at present. In the spontaneous decomposition of feldspars, which may be described as silicates of alumina combined with silicates of potash, soda and lime, these latter bases are removed, together with a portion of silica; and there remains as the final result of the process, a hydrous silicate of alumina, which constitutes kaolin or clay. This change is favoured by mechanical division; and Daubrée has shown that by the prolonged attrition of fragments of granite under water, the softer and readily cleavable feldspar is in great part reduced to an impalpable powder, while the uncleavable grains of quartz are only rounded, and form a readily subsiding sand; the water at the same time dissolving from the feldspar a certain portion of silica, and of alkali. It has been repeatedly observed, where potash and soda-feldspars are associated, that the latter is much the more readily decomposed, becoming friable, and finally being reduced to clay, while the orthoclase is unaltered. The result of combined chemical and mechanical agencies acting upon rocks which contain quartz, with orthoclase, and a soda-feldspar such as albite or oligoclase, would thus be a sand, made up chiefly of quartz and potash-feldspar, and a finely divided and suspended clay, consisting for the most part of kaolin, and of partially decomposed soda-feldspar, mingled with some of the smaller particles of orthoclase and of quartz. With this sediment will also be included the oxide of iron, and the earthy carbonates set free by the sub-aërial decomposition of silicates like pyroxene and the anorthic feldspars, or formed by the action of the carbonate of soda derived from the latter upon the lime salts and magnesia salts of sea-water. The debris of hornblende and pyroxene will also be found in this finer sediment. This process is evidently the one which must go on in the wearing away of rocks by aqueous agency, and explains the fact that while quartz, or an excess of combined silica, is for the most part wanting in rocks which contain a large proportion of alumina, it is generally abundant in those rocks in which potash-feldspar predominates.

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So long as this decomposition of alkaliferous silicates is sub-aërial, the silica and alkali are both removed in a soluble form. The process is often however submarine, or subterranean, taking place in buried sediments, which are mingled with carbonates of lime and magnesia. In such cases the silicate of soda set free, re-acts either with these earthy carbonates, or with the corresponding chlorids of sea-water, and forms in either event a soluble soda-salt, and insoluble silicates of lime and magnesia, which take the place of the removed silicate of soda. The evidence of such a continued reaction between alkaliferous silicates and earthy carbonates is seen in the large amounts of carbonate of soda, with but little silica, which infiltrating waters constantly remove from argillaceous strata; thus giving rise to alkaline springs, and to natron lakes. In these waters it will be found that soda greatly predominates, sometimes almost to the exclusion of potash. This is due not only to the fact that soda-feldspars are more readily decomposed than orthoclase, but to the well-known power of argillaceous sediments to abstract from water the potash salts which it already holds in solution. Thus when a solution of silicate, carbonate, sulphate, or chlorid of potassium is filtered through common earth, the potash is taken up, and replaced by lime, magnesia, or soda, by a double decomposition between the soluble potash salt and the insoluble silicates or carbonates of the latter bases. Soils in like manner remove from infiltrating waters, ammonia, and phosphoric and silicic acids, the bases which were in combination with these being converted into carbonates. The drainage-water of soils, like that of most mineral springs, contains only carbonates, chlorids, and sulphates of lime, magnesia, and soda; the ammonia, potash, phosphoric and silicic acids being retained by the soil.

The elements which the earth retains or extracts from waters are precisely those which are removed from it by growing plants. These, by their decomposition under ordinary conditions, yield their mineral matters again to the soil; but when decay takes place in water, these elements become dissolved, and hence the waters from peat bogs and marshes contain large amounts of potash and silica in solution, which are carried to the sea, there to be separated—the silica by protophytes, and the potash by algæ, which latter, decaying on the shore, or in the ooze at the bottom, restore the alkali to the earth. The conditions under which the vegetation of the coal formation grew, and was preserved, being similar to those of peat, the soils became exhausted of potash, and are seen in the fire-clays of that period.

Another effect of vegetation on sediments is due to the reducing or de-oxidizing agency of the organic matters from its decay. These, as is well known, reduce the peroxide of iron to a soluble protoxide, and remove it from the soil, to be afterwards deposited in the forms of iron ochre and iron ores, which by subsequent alteration become hard, crystalline and insoluble. Thus, through the agency of vegetation, is the iron oxide of the sediments withdrawn from the terrestrial circulation; and it is evident that the proportion of this element diffused in the more recent sediments must be much less than in those of ancient times. The reducing power of organic matter is farther shown in the formation of metallic sulphurets; the reduction of sulphates having precipitated in this insoluble form the heavy metals, copper, lead, and zinc; which, with iron, appear to have been in solution in the waters of early times, but are now by this means also abstracted from the circulation, and accumulated in beds and fahlbands, or by a subsequent process have been redissolved and deposited in veins. All analogies lead us to the conclusion that the primeval condition of the metals, and of sulphur, was, like that of carbon, one of oxidation, and that vegetable life has been the sole medium of their reduction.

The source of the carbonates of lime and magnesia in sedimentary strata is two-fold:—first, the decomposition of silicates containing these bases, such as anorthic feldspars and pyroxene; and second, the action of the alkaline carbonates formed by the decomposition of feldspars, upon the chlorids of calcium and magnesium, originally present in sea-water; which have thus, in the course of ages, been in great part replaced by chlorid of sodium. The clay, or aluminous silicate which has been deprived of its alkali, is thus a measure of the carbonic acid removed from the air, of the carbonates of lime and magnesia precipitated, and of the amount of chlorid of sodium added to the waters of the primeval ocean.

The coarser sediments, in which quartz and orthoclase prevail, are readily permeable to infiltrating waters, which gradually remove from them the soda, lime, and magnesia, which they contain; and if organic matters intervene, the oxide of iron; leaving at last little more than silica, alumina, and potash—the elements of granite, trachyte, gneiss, and mica-schist. On the other hand the finer marls and clays, resisting the penetration of water, will retain all their soda, lime, magnesia, and oxide of iron; and containing an excess of alumina, with a small amount of silica, will by their metamorphism, give rise to basic lime and soda-feldspars, and to pyroxene and hornblende—the elements of diorites and dolerites. In this way, the operation of the chemical and mechanical causes which we have traced, naturally divides all the crystalline silico-aluminous rocks of the earth's crust into two types. These correspond to the two classes of igneous rocks, distinguished first by Professor Phillips, and subsequently by Durocher, and by Bunsen, as derived from two distinct magmas; which these geologists imagine to exist beneath the solid crust, and which the latter denominates the trachytic and pyroxenic types. I have however elsewhere endeavoured to show that all intrusive or exotic rocks are probably nothing more than altered and displaced sediments, and have thus their source within the lower portions of the stratified crust, and not beneath it.

It may be well in this place to make a few observations on the chemical conditions of rock-metamorphism. I accept in its widest sense the view of Hutton and Bouë, that all the crystalline stratified rocks have been produced by the alteration of mechanical and chemical sediments. The conversion of these into definite mineral species has been effected in two ways: first by molecular changes; that is to say, by crystallization, and a re-arrangement of particles; and, secondly by chemical reactions between the elements of the sediments. Pseudomorphism, which is the change of one mineral species into another, by the introduction, or the elimination of some element or elements, presupposes metamorphism; since only definite mineral species can be the subjects of this process. To confound metamorphism with pseudomorphism, as Bischoff, and others after him, have done, is therefore an error. It may be farther remarked, that although certain pseudomorphic changes may take in some mineral species, in veins, and near to the surface, the alteration of great masses of silicated rocks by such a process is as yet an unproved hypothesis.

The cases of local metamorphism in proximity to intrusive rocks go far to show, in opposition to the views of certain geologists, that heat has been one of the necessary conditions of the change. The source of this has been generally supposed to be from below;

but to the hypothesis of alteration by ascending heat, Naumann has objected that the inferior strata in some cases escape change, and that in descending, a certain plane limits the metamorphism, separating the altered strata above, from the unaltered ones beneath; there being no apparent transition between the two. This, taken in connexion with the well-known fact that in many cases the intrusion of igneous rocks causes no apparent change in the adjacent unaltered sediments, shows that heat and moisture are not the only conditions of metamorphism. In 1857, I showed by experiments, that in addition to these conditions, certain chemical reagents might be necessary; and that water impregnated with alkaline carbonates and silicates, would, at a temperature not above that of 212° F., produce chemical reactions among the elements of many sedimentary rocks, dissolving silica, and generating various silicates (1). Some months subsequently, Daubrée found that in the presence of solutions of alkaline solutions, at temperatures above 700° F., various silicious minerals, such as quartz, feldspar, and pyroxene, could be made to assume a crystalline form; and that alkaline silicates in solution at this temperature would combine with clay to form feldspar and mica (2). These observations were the complement of my own, and both together showed the agency of heated alkaline waters to be sufficient to effect the metamorphism of sediments by the two modes already mentioned,—namely, by molecular changes, and by chemical reactions. Following upon this, Daubrée observed that the thermal alkaline spring of Plombieres, with a temperature of 160° F., had in the course of centuries, given rise to the formation of zeolites, and other crystalline silicated minerals, among the bricks and cement of the old Roman baths. From this he was led to suppose that the metamorphism of great regions might have been effected by hot springs; which, rising along certain lines of dislocation, and thence spreading laterally, might produce alteration in strata near to the surface, while those beneath would in some cases escape change (3). This ingenious hypothesis may serve in

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1. Proc. Royal Soc. of London, May 7, 1857; and Philos. Mag. (4) xv., 68; also Amer. Jour. Science (2), xxii., and xxv., 435.

2. Comptes Rendus de l'Acad., Nov. 16, 1857; also Bull. Soc. Geol. de France (2), xv., 103.

3. It should be remembered that normal or regional metamorphism is in no way dependent upon the proximity of unstratified or igneous rocks, which are rarely present in metamorphic districts. The ophiolites,

some cases to meet the difficulty pointed out by Naumann; but while it is undoubtedly true in certain instances of local metamorphism, it seems to be utterly inadequate to explain the complete and universal alteration of areas of sedimentary rocks, embracing many hundred thousands of square miles. On the other hand, the study of the origin and distribution of mineral springs, shows that alkaline waters (whose action in metamorphism I first pointed ou and whose efficient agency Daubrée has since so well shown), are confined to certain sedimentary deposits, and to definite stratigraphical horizons; above and below which saline waters wholly different in character are found impregnating the strata. This fact seems to offer a simple solution of the difficulty advanced by Naumann, and a complete explanation of the theory of metamorphism of deeply buried strata by the agency of ascending heat; which is operative in producing chemical changes only in those strata in which soluble alkaline salts are present. (4).

When the sedimentary strata have been rendered crystalline by metamorphism, their permeability to water, and their alterability, become greatly diminished; and it is only when again broken down by mechanical agencies to the condition of soils and sediments, that they once more become subject to the chemical changes which have just been described. Hence, the mean composition of the argillaceous sediments of any geological epoch, or

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amphibolites, euphotides, diorites, and granites of such regions, which it has been customary to regard as exotic or intrusive rocks, are in most cases indigenous, and are altered sediments. I have elsewhere shown that the great outbursts of intrusive dolerites, diorites, and trachytes in south-eastern Canada are found, not among the metamorphic rocks, but among the unaltered strata along their margin, or at some distance removed; and I have endeavoured to explain this by the consideration that the great volume of overlying sediments, which, by retaining the central heat, aided in the alteration of the strata now exposed by denudation, produced a depression of the earth's surface, and forced out the still lower and softened strata along the lines of fracture which took place in the regions beyond. See my paper "On some Points in American Geology," Amer. Jour. Science (2), xxxi. 414., and Can. Nat. vi. 81.

4. See Report of the Geological Survey of Canada, 1853–6, pp. 479, 480; also Canadian Naturalist, vol. vii., p. 262. For a consideration of the relations of mineral waters to geological formations, see "General Report on the Geology of Canada," p. 561; also chap. xix. on "Sedimentary and Metamorphic Rocks;" where most of the points touched in the present paper are discussed at greater length.

in other words, the proportion between the alkalies and the alumina, will depend not only upon the age of the formation, but upon the number of times which its materials have been broken up, and the periods during which they have remained unmetamorphosed, and exposed to the action of infiltrating waters. Thus for example, that portion of the Lower Silurian rocks in Canada which became metamorphosed before the close of the palæozoic period, will have lost less of its soluble bases than the portion of the same age which still remains in the form of unaltered shales and sandstones. Of these again, such parts as remain undisturbed by folds and dislocations, will retain a larger portion of bases than those strata in which such disturbances have favored the formation of mineral springs; which even now are active in removing soluble matters from these rocks. The crystalline Lower Silurian rocks in Canada may be compared with those of the older Laurentian series on the one hand, and with the Upper Silurian or Devonian on the other; but when these are to be compared with the crystalline strata of secondary or tertiary age in the Alps, it cannot be determined whether the sediments of which these were formed, (and which may be supposed, for illustration, to have been directly derived from palæozoic strata), existed up to the time of their translation, in a condition similar to that of the altered, or of the unaltered Lower Silurian rocks of Canada. The proportion between the alkalies and the alumina in the argillaceous sediments of any given formation is not therefore in direct relation to its age; but indicates the extent to which these sediments have been subjected to the influences of water, carbonic acid, and vegetation. If however it may be assumed that this action, other things being equal, has on the whole, been proportionate to the newness of the formation, it is evident that the chemical and mineralogical composition of different systems of rocks must vary with their antiquity; and it now remains to find in their comparative study a guide to their respective ages.

It will be evident that silicious deposits, and chemical precipitates, like the carbonates and silicates of lime and magnesia, may exist with similar characters in the geological formations of any age; not only forming beds apart, but mingled with the impermeable silico-aluminous sediments of mechanical origin. Inasmuch as the chemical agencies giving rise to these compounds were then most active, they may be expected in greatest abundance in the rocks of the earlier periods. In the case of the permeable and more highly silicious class of sediments already noticed, whose chief elements are silica, alumina, and alkalies, the deposits of different ages will be marked chiefly by a progressive diminution in the amount of potash, and the disappearance of the soda which they contain. In the oldest rocks the proportion of alkali will be nearly or quite sufficient to form orthoclase and albite with the whole of the alumina present; but as the alkali diminishes, a portion of the alumina will crystallize, on the metamorphism of the sediments, in the form of a potash-mica, such as muscovite or margarodite. While the oxygen ratio between the alumina and the alkali in the feldspars just named is 3 : 1, it becomes 6 : 1 in margarodite, and 12 : 1 in muscovite. The appearance of these micas in a rock denotes then a diminution in the amount of alkali, until in some strata the feldspar almost entirely disappears, and the rock becomes a quartzose mica-schist In sediments still farther deprived of alkali, metamorphism gives rise to schists filled with crystals of kyanite, or of andalusite; which are simple silicates of alumina, into whose composition alkalies do not enter; or in case the sediment still retains oxide of iron, staurotide and iron-alumina garnet take their place. The matrix of all these minerals is generally a quartzose mica-schist. The last term in this exhaustive process appears to be represented by the disthene and pyrophyllite rocks, which occur in some regions of crystalline schists.

In the second class of sediments we have alumina in excess, with a small proportion of silica, and a deficiency of alkalies, besides a variable proportion of silicates or carbonates of lime, magnesia, and oxide of iron. The result of the processes already described will produce a gradual diminution in the amount of alkali, which is chiefly soda. So long as this predominates, the metamorphism of these sediments will give rise to feldspars like oligoclase, labradorite, or scapolite (a dimetric feldspar); but in sediments where lime replaces a great proportion of the soda, there appears a tendency to the production of denser silicates, like lime-alumina garnet, and epidote, or zoisite, which replace the soda-lime feldspars. Minerals like the chlorites, and chloritoid, are formed when magnesia and iron replace lime. In all these cases the excess of the silicates of earthy protoxides over the silicate of alumina is represented in the altered strata by hornblende, pyroxene, olivine, and similar species; which give rise by their admixture with the double aluminous silicates, to diorite, diabase, euphotide, eklogite, and similar compound rocks.

In eastern North America, the crystalline strata, so far as yet studied, may be conveniently classed in five groups, corresponding to as many different geological series, four of which will be considered in the present paper.

I. The Laurentian system represents the oldest known rocks of the globe, and is supposed to be the equivalent of the Primitive Gneiss formation of Scandinavia, and that of the Western Islands of Scotland, to which also the name of Laurentian is now applied. It has been investigated in Canada along a continuous outcrop from the coast of Labrador to Lake Superior, and also over a considerable area in northern New York.

II. Associated with this system is a series of strata characterized by a great development of anorthosites, of which the hypersthenite, or opalescent feldspar-rock of Labrador, may be taken as a type. These strata overlie the Laurentian gneiss, and are regarded as constituting a second and more recent group of crystalline rocks, to which the name of the Labrador series may be provisionally given. From evidence recently obtained, Sir William Logan conceives it probable that this series is unconformable with the older Laurentian system, and is separated from it by a long interval of time.

III. In the third place is a great series of crystalline schists, which are in Canada referred to the Quebec group, an inferior part of the Lower Silurian system. They appear to correspond both lithologically and stratigraphically with the Schistose group of the Primitive Slate formation of Norway, as recognized by Naumann and Keilhau, and to be there represented by the strata in the vicinity of Drontheim, and those of the Dofrefeld. The Huronian series of Canada in like manner appears to correspond to the Quartzose group of the same Primitive Slate formation (5). It consists of sandstones, imperfect varieties of gneiss, diorites, silicious and feldspathic schists passing into argillites, with limestones, and great beds of hematite. Though more recent than the Laurentian and Labrador series, these strata are older than the Quebec group; yet from their position to the westward of the greatest accumulation of sediments, they have been subjected to a less complete metamorphism than the palæozoic strata of the East. The Huronian series is as yet but imperfectly studied, and for the present will not be further considered.

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(5) See Macfarlane—Primitive Formations of Norway and Canada compared—Canadian Naturalist, vii., 113, 162.

IV. In the fourth place are to be noticed the metamorphosed strata of Upper Silurian and Devonian age, with which may also be included those of the Carboniferous system in eastern New England. This group has as yet been imperfectly studied, but presents interesting peculiarities.

In the oldest of these, the Laurentian system, the first class of aluminous rocks takes the form of granitoid gneiss, which is often coarse grained and porphyritic. Its feldspar is frequently a nearly pure potash orthoclase, but sometimes contains a considerable proportion of soda. Mica is often almost entirely wanting, and is never abundant in any large mass of this gneiss, although small bands of mica-schist are occasionally met with. Argillites, which from their general predominance of potash and of silica, are related to the first class of sediments, are, so far as known, wanting throughout the Laurentian series; nor is any rock here met with, which can be regarded as derived from the metamorphism of sediments like the argillites of more modern series. Chloritic and chiastolite schists, and kyanite are, if not altogether wanting, extremely rare in the Laurentian system. The aluminous sediments of the second class are however represented in this system by a diabase made up of dark green pyroxene and bluish labradorite, often associated with a red alumino-ferrous garnet. This latter mineral also sometimes constitutes small beds, often with quartz, and occasionally with a little pyroxene. These basic aluminous minerals form however but an insignificant part of the mass of strata. This system is farther remarkable by the small amount of ferruginous matter diffused through the strata; from which the greater part of the iron seems to have been removed, and accumulated in the form of immense beds of hematite and magnetic iron. Beds of pure crystalline plumbago also characterize this series, and are generally found with the limestones. These are here developed to an extent unknown in more recent formations; and are associated with beds of crystalline apatite, which sometimes attain a thickness of several feet. The serpentines of this series, so far as yet studied in Canada, are generally pale colored, and contain an unusual amount of water, a small proportion of oxide of iron, and neither chrome nor nickel; both of which are almost always present in the serpentines of the third series.

The second or Labrador series is characterized, as already remarked, by the predominance of great beds of anorthosite, composed chiefly of triclinic feldspars, which vary in composition from anorthite to andesine. These feldspars sometimes form mountain masses, almost without any admixture, but at other times include portions of pyroxene, which passes into hypersthene. Beds of nearly pure pyroxenite are met with in this series, and others which would be called hyperite and diabase. These anorthosite rocks are frequently compact, but are more often granitoid in structure. They are generally greyish, greenish, or bluish in colour, and become white on the weathered surfaces. The opalescent labradorite-rock of Labrador is a characteristic variety of these anorthosites; which often contain small portions of red garnet and brown mica, and more rarely, epidote, and a little quartz. They are sometimes slightly calcareous. Magnetic iron and ilmenite are often disseminated in these rocks, and occasionally form masses or beds of considerable size. These anorthosites constitute the predominant part of the Labrador series, so far as yet examined. They are however associated with beds of quartzose orthoclase gneiss, which represent the first class of aluminous sediments, and with crystalline limestones; and they will probably be found, when further studied, to offer a complete lithological series. These rocks have been observed in several areas among the Laurentide Mountains, from the coast of Labrador to Lake Huron, and are also met with among the Laurentian rocks of the Adirondack Mountains; of which according to Emmons, they form the highest summits.

In the third series, which we have referred to the Lower Silurian age, the gneiss is sometimes granitoid, but less markedly so than in the first; and it is much more frequently micaceous, often passing into micaceous schist, a common variety of which contains disseminated a large quantity of chloritoid. Argillites abound, and under the influence of metamorphism sometimes develop crystalline orthoclase. At other times they are converted into a soft micaceous mineral, and form a kind of mica-schist. Chiastolite and staurotide are never met with in the schists of this series, at least in its northern portions, throughout Canada and New England. The anorthosites of the Labrador series are represented by fine grained diorites, in which the feldspar varies from albite to very basic varieties, which are sometimes associated with an aluminous mineral allied to chlorite in composition. Chloritic schists, freqently accompanied by epidote, abound in this series. The great predominance of magnesia in the forms of dolomite, magnesite, steatite and serpentine, is also characteristic of portions of this series. The latter, which forms great beds (ophiolites), is marked by the almost constant presence of small portions of the oxides of chrome and nickel. These metals are also common in the other magnesian rocks of the series; green chrome-garnets, and chrome-mica occur; and beds of chrome iron ore are found in the ophiolites of the series. It is also the gold-bearing formation of eastern North America, and contains large quantities of copper ores in interstratified beds resembling those of the Permian schists of Mansfeld and Hesse. In some parts of this series pure limestones occur, which contain various crystalline minerals common also to the Laurentian limestones, and to those of the fourth series. The only graphite which has been found in the third series, is in the form of impure plumbaginous shales.

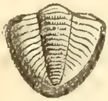
The metamorphic rocks of the fourth series, as seen in south-eastern Canada, are for the greater part quartzose and micaceous schists, more or less feldspathic; which in the neighboring States become remarkable for a great development of crystals of staurotide and of red garnet. A large amount of argillite occurs in this series; and when altered, whether locally by the proximity of intrusive rock, or by normal metamorphism, exhibits a micaceous mineral, and crystals of andalusite; so that it becomes known as chiastolite slate in its southern extension. Granitoid gneiss is still associated with these crystalline schists. Gold is not confined to the third series, but is also met with in veins cutting the argilites of Upper Silurian age. The crystalline limestones and ophiolites of eastern Massachusetts, which are probably of this series, resemble those of the Laurentian system; and the coal beds in that region are in some parts, changed into graphite. It is to be remarked that the metamorphic strata of the third and fourth series are contiguous throughout their extent, so far as examined, but are everywhere separated from the Laurentian and Labrador series by a zone of unaltered palæzoic rocks.

Large masses of intrusive granite occur among the crystalline strata of the fourth series, but are rare or unknown among the older metamorphic rocks in Canada. The so-called granites of the Laurentian and Lower Silurian appear to be in every case indigenous rocks; that is to say, strata altered *in situ*, and still retaining evidences of stratification. The same thing is true with regard to the ophiolites and the anorthosites of both series; in all of which the general absence of great masses of unstratified rock is especially noticeable. No evidences of the hypothetical granitic substratum are met with in the Laurentian system, although this is in one district penetrated by great masses of syenite, orthophyre, and dolerite. Granitic veins, with minerals containing the rarer elements, such as boron, fluorine, lithium, zirconium, and glucinum, are met with alike in the oldest and the newest gneiss in North America. These however, I regard as having been formed, like metalliferous veins, by aqueous deposition in fissures in the strata.

The above observations upon the metamorphic strata of a wide region seem to be in conformity with the chemical princiciples already laid down in this paper; which it remains for geologists to apply to the rocks of other regions, and thus determine whether they are susceptible of a general application. I have found that the blue crystalline labradorite of the Labrador series of Canada is exactly represented by specimens from Scarvig, in Skye; and the ophiolites of Iona resemble those of the Laurentian series in Canada. Many of the rocks of Donegal appear to me lithologically identical with those of the Laurentian period; while the serpentines of Aghadoey, containing chrome and nickel, and the andalusite and kyanite-schists of other parts of Donegal, cannot be distinguished from those which characterize the altered palæozoic strata of Canada. It is to be remarked that chrome and nickel-bearing serpentines are met with in the same geological horizon in Canada and Norway; and that those of the Scottish Highlands, which contain the same elements, belong to the newer gneiss formation; which, according to Sir Roderick Murchison, would be of similar age. The serpentines of Cornwall, the Vosges, Mount Rosa, and many other regions, agree in containing chrome and nickel; which on the other hand, seem to be absent from the serpentines of the Primitive Gneiss formation of Scandinavia. It remains to be determined how far chemical and mineralogical differences, such as those which have been here indicated, are geological constants. Meanwhile it is greatly to be desired that future chemical and mineralogical investigations of crystalline rocks should be made with this question in view; and that the metamorphic strata of the British Isles, and the more modern ones of Southern and Central Europe, be studied with reference to the important problem which it has been my endeavour, in the present paper, to lay before the Society.

MONTREAL, January, 25, 1863.

ART. XVII.—*Description of a new species of* PHILLIPSIA, *from the lower Carboniferous rocks of Nova Scotia;* by E. BILLINGS, F.G.S.



PHILLIPSIA HOWI. (N. SP.)

P. HOWI. Pygidium. The tubercles on the side lobes were overlooked in the drawing, the specimen being nearly smooth.

Description.—Pygidium semi-elliptical, strongly convex, width at the anterior margin a little less than the length, seventeen or eighteen articulations in the axis, side lobes with ten or twelve ribs and a smooth border. The axis is very prominent, about one-third the width, gradually and uniformly tapering and terminating abruptly at five-sixths of the whole length in an obtusely rounded apex. The ribs on the axis are depressed convex, becoming smaller and more crowded towards the apex, each with eight or nine small tubercles, which are confined to the middle third of the width of the axis, and are situated near the posterior margin of the ribs. The side lobes have ten or twelve depressed convex ribs, the last three indistinct, the first three or four with a very obscure fine groove near the posterior edge, in the outer third of the length. The smooth border is about one-fourth the width of the side lobes at the anterior angles, but a little wider behind; all the space behind the apex of the axis is smooth. Each rib has nine or ten small tubercles near its posterior margin. On the posterior third of the pygidium there is an obscure shallow groove along the inner edge of the smooth border.

Length of the specimen six lines; width at the anterior margin, nearly the same, about one-sixth of a line less.

This species resembles *P. Meramecensis* (Shumard), but has a greater number of ribs in the axis of the pygidium.

P. insigens (Winchell) is a very closely allied species. The pygidium is thus described by Prof. Winchell in the Proc. Acad. Nat. Sci., Phi. January 1863, p. 24.

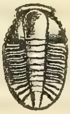
"Pygidium very convex, semi-elliptic, the axis very prominent and forming about one third the width at the anterior margin; consisting of twelve to fourteen rings each bearing six small tubercles, the whole of which are arranged in six longitudinal rows; the tubercles often worn down on the exterior of the test, but always well defined in the cast; lateral lobes bent rather abruptly downwards, having ten ribs, which become indistinct and disappear toward the margin, and are entirely wanting over the narrow space behind the axis ; the anterior ribs shewing a faint median groove toward their vanishing extremities, and a few of the posterior ones bearing feeble tuberculations toward their axial extremities".

The only difference of any importance between the two species appears to be the greater number of rings in the axis of our species. This however will most probably turn out to be correlated with differences in the glabella.

Dedicated to Prof. H. How, King's College, Windsor, Nova Scotia.

Locality and Formation.—Kennetcook, Nova Scotia; lower carboniferous.

ART. XVIII.—*Description of a new Trilobite from the Quebec Group.* By T. DEVINE, F. R. G. S., C. L. Department, Quebec.



MENOCEPHALUS SALTERI, (N. S.P.)

(Enlarged two diameters.)

DESCRIPTION.—form oblong—oval.—Entire length three lines and width at posterior margin of the head one and one fifth line—front of head and posterior margin of the tail broadly rounded—sides parallel.

HEAD—Semicircular, two fifths of the entire length, strongly convex, posterior margin marked by a well defined furrow which curves round the lateral angles anteriorly.

GLABELLA—Ovate, narrow at the base, and broadly rounded in front, extending anteriorly beyond the fixed cheeks, prominently convex with a very narrow flat rim forming an arch round the front.

THORACIC SEGMENTS—Six or seven, flat lying close to each other with a broad, deep groove extending outwards to the tips which are bent down.

AXIS—Tapering regularly from the front of the head to the posterior margin of the tail, convex, as wide as the pleuræ in front and less posteriorily, the rings of the axis run into the groves of the pleuræ—marked by a deep grove.

TAIL—Semicircular, the lateral lobes marked by two or three ribs with a deep grove as in the pleuræ, owing to which and the smallness of the specimen, it is difficult to perceive the line of separation between the body and tail.

The eyes and free cheeks are absent in all the specimens.

AFFINITIES—In form and number of pleuræ it resembles *Cyphoniscus Socialis* (Salter) but differs from it in details of structure —the pleuræ are of a different type, having the groove running along the middle, straight outwards, and not obliquely outwards and downwards, as in Salter's figure. The pygidium is entire but is as deep grooved as the pleuræ, the whole form is not so convex, and the pleuræ are not facetted.

It appears from the outward edge of the fixed cheeks that the facial suture cuts the margin in front and posterior margin far outward, The head of *Menocephalus Salteri* resembles closely that of *Bathyurus Saffordi* in the flat arched border in front of the Glabella, and in the three convex lobes into which the head is divided.

Dedicated to J. W. Salter, Esq, Palæontologist of the Geological Survey of Great Britain.

This beautiful little crustacean was found at Point Levis in the Quebec Group of Rocks, in the same band of Limestone as *Olenus Logani.*

BOTANICAL SOCIETY OF CANADA.

The usual monthly meeting was held in the University Hall, Kingston C. W. on Friday evening, March 13, Rev. Prof. Williamson, LL.D., presiding.

The following papers were read;—

1. Remarks on the Flora of Brockville, C.W., and vicinity. By Robert Jardine, B.A.

2. Communication from Dr. Francis W. Bird, with fresh specimens of broad-leaved evergreens from the woods of Virginia, including "Live Oak," from within the walls of Fortress Munroe, Hollies, &c. Read by Prof. Dickson, M.D.

3. List of ferns collected in the neighbourhood of Hamilton, C.W. By Judge Logie.

4. On the Flora of Beckwith, with remarks on the physical geography and industrial products of the locality. By Josiah Jones Bell.

5. Remarks on the cultivation of flax in Canada. By. Rev. Prof. Williamson.

The following were exhibited :—

A Fairy Rose in bloom, from Mrs. Prof. Lawson ; specimens of an Algia, apparently identical with a long lost plant, the *Lemania variegata* of Bishop Agardh, from Mr. Marcoun, Belleville ; specimens of Brockville Plants, from Mr. Jardine ; a flower of very large size, of the Night Flowering Cereus, preserved in alcohol, which had been presented to the college museum by Mrs. McLeod.

Letters were read by Prof. Lawson, from Thomas Briggs, jr. ; Dr. Muller, Government Botanist, Melbourne, advising the transmission to the Society of a large collection of Australian plants ; Dr. Grant, Ottawa, accepting of membership, &c.

The Secretary laid on the table the first number of a new monthly periodical, the Journal of Botany, British and Foreign, edited by Dr. B. Seemann, London.

The librarian presented donations to the library from the American Philosophical Society ; Dr. Muller, Melbourne ; and Prof. Asa Gray, Harvard.

ENTOMOLOGICAL SOCIETY OF CANADA.

A meeting of Canadian Entomologists was held in Toronto, in the rooms of the Canadian Institute on Thursday, the 16th of April, for the purpose of taking into consideration the propriety of forming a Society for the advancement of Entomological pursuits.

The following gentlemen were present :—Rev. Prof. W. Hincks F.L.S., Prof. H. Croft, D.C.L., Beverley R. Morris, M.D., J. H. Sangster, A.M., and J. Hubbert, of Toronto ; Thomas Cowdry, M.D., and H. Cowdry, York Mills ; Rev. C. J. S. Bethune, M.A., Cobourg, and W. Saunders, London.

Prof. Hincks was appointed chairman, and Mr. Bethune, secretary *pro tem.*

Letters of apology for non-attendance were read from E. Billings, F.G.S., Montreal ; R. V. Rogers, Kingston ; T. Reynolds, Hamilton ; B. Billings, Prescott ; Rev. V. Clementi, B.A., Peterborough, and E. Baynes Reed, London. These gentlemen expressed regret at their inability to attend, and pledged themselves to do all in their power to further the interests of the society.

The following resolutions were then unanimously adopted :

1st. That a Society be formed to be called the Entomological Society of Canada, consisting of all students and lovers of Entomology, who shall express their desire to join it and conform to its regulations.

2nd. That its officers shall consist of a President, a Secretary-Treasurer, and a Curator, to be elected annually at the first general meeting in each year, whose duty it shall be to manage the affairs of the Society.

3rd. That the annual contribution of members shall be two dollars, to be paid in advance.

4th. That application be made to the Canadian Institute for the use of a room in their building for the purposes of the Society.

5th. That two separate collections be formed, a general one to be the property of the Canadian Institute, and a duplicate one to be the property of the Society, and to consist of all surplus specimens contributed to the Society by members; and that all members be at liberty to exchange species for species under the supervision of the Curator.

6th. That meetings be held at 3 P. M., on the first Tuesday in each month, and that special meetings may be called when necessary by the Officers.

7th. That Prof. Croft be President for the present year; that Wm. Saunders be the Secretary-Treasurer, and J. Hubbert the Curator.

8th. That the President be authorized to bring the subject before the Council of the Canadian Institute at its next meeting.

The following papers were then read to the Society :—" Insect Life in Canada, March and April;" by the Rev. C. J. S. Bethune, and " A Synopsis of Canadian ARCTIIDÆ ;" by W. Saunders, the latter illustrated by a complete series of specimens.

A number of interesting insects were brought to the meeting for inspection, chiefly from the collections of Dr. Morris and W. Saunders. Among others, Canadian specimens of the following were much admired. *Limenitis ursula*, *Vanessa cœnia*, *Mellitœa nycteis*, *M. phœton*, *Thecla niphon*, *T. mopsus*, *T. laeta*, *Lycœna neglecta*, *Polyommatus dorcas*, *Hesperia mystic*, *H. wamsutta* and *Pamphila numitor*. A specimen of *Colias eurytheme* though not itself Canadian, was regarded with great interest from the fact that a specimen had been captured last fall near St. Catherines by D. W. Beadle.

The pretty little moths *Glaucopis semidiaphana* and *Melanippe propriaria* were duly represented; also beautiful specimens of *Arctia dione* and *Sphinx drupiferarum.*

Magnificent specimens of *Ceratocampa regalis* and *Dryocampa imperialis* were exhibited, and although not natives, the probability of their being yet found with us gave them an additional interest.

Among the coleoptera we observed some rarities, for example: *Xyloryctes satyrus*, *Canthon chalcites*, *Chlœnius lithophilus*, *Calosoma frigidum*, *Geotrupes splendidus*, *Bolbocerus Lazarus*, *Aphonus frater*, and *Leptura nitens*, all natives of Canada.

After a careful examination of all that was interesting, the meeting adjourned, each one highly pleased with the results of the gathering.

The application for the use of a room in the building of the Canadian Institute, for the purposes of the Society, was brought before the Council, by the President, at their meeting on Saturday the 18th, when they very liberally granted it free of expense.

The Society thus formed will we trust be a prosperous one. The number of Entomologists in this country is not large, but they are amply sufficient to sustain an organization of this sort. The advantages the Society offers to its members are not by any means small. The general collection will be open to all for purposes of reference and comparison, and will thus afford valuable opportunities to those who wish to name their specimens; while the cabinet of duplicates will offer means of exchange with al parts of Canada. It is intended that duplicate copies of Entomological papers, published by those connected with the Society, shall be left with the curator for distribution among members. It is probable also that as soon as the funds will permit, an Entomological library will be added to the other attractions in the Society's room; and that a stock of pins will be purchased from which members may obtain supplies at cost price.

That the meetings of the Society may be made as interesting and attractive as possible, it is desired that members at a distance should furnish short monthly records of interesting captures in their localities, always accompanied when convenient with specimens of the insects.

All lovers of Entomology may become members of the Society by remitting the amount of the yearly subscription to the secretary-treasurer. W. SAUNDERS, *London.*

NATURAL HISTORY SOCIETY.

ORDINARY MEETING, FEBRUARY 23.

Principal Dawson, one of the Presidents, in the Chair.

After some routine business a Committee was named to "take steps in connection with the Horticultural Society for the establishment of a Botanical Garden."

Several names were proposed for membership, after which the following papers were read and presented:

On a new method of preparing Chlorine, Carbonate of Soda, Sulphuric Acid, and Hydrochloric Acid; by Thomas MacFarlane. Read by Dr. Hunt.

On the Superficial Geology of the Gaspé Peninsula; by Robt. Bell.

On the parallelism of the Quebec Group with the Llandeilo of England and Australia, and with the Chazy and Calciferous formations; by E. Billings, F.G.S.

On the Birds of North America; by B. R. Ross. Read by Dr. Hingston.

Notes on the Diatomaceæ from the St. John River; by Prof. L. W. Bailey, of the University of New Brunswick. Presented by Dr. Dawson.

ORDINARY MEETING, MARCH 30.

Rev. Dr. De Sola, Chairman of Council, in the Chair.—About forty members were present.

The following gentlemen were elected corresponding members:—

Hugh E. Montgomerie, of London; Charles Waterton, near Wakefield, England; Professor Bailey, of Fredericton, N. B.; N. W. Bethune, of Ottawa.

The following gentlemen were elected ordinary members:—

Alexander Urquhart, Thos. Leeming, Francis Scholes, Alfred Brown, Prof. Small, late of Lincoln College, Oxford; J. F. Whiteaves, F.G.S., &c., &c.

The following donations were presented:—

From N. W. Bethune, a Canada Bank Note of the year 1792.

From T. Devine, Quebec, sixteen specimens of Electrotype casts of Fossils from Point Levi.

From Mr. Charlton, Laprairie, fish for the Aquaria.

For the Library.—From Principal Dawson: A pamphlet on the Devonian Flora of Eastern America; a vol., Rhopalocera Afriæ Australis, from W. S. M. D'Urban; and the usual magazines and papers.

After other routine business the following papers were read:—

1. *On Amendments of the Game Laws of Canada*, by A. Rimmer. The author explained and advocated a number of amendments which have been proposed by the Game Preservation Society, and which it was believed would materially tend to the preservation of game birds, as well as of those smaller birds, the wanton slaughter of which is so injurious to agriculture and horticulture.

2. *On a New Trilobite from the Quebec Group*, by T. Devine. This paper was read by Sir W. E. Logan, who noticed, in introducing it, the successful labours of Mr. Devine in collecting in these ancient rocks, the fossils of which are of so great interest in connection both with the questions as to the age of the group and with general geology. The fossil now described was of special interest, as giving the complete characters of a genus previously known only by parts of the body.

3. *On the Geology of the County of St. John, New Brunswick*, by G. F. Matthew.

This paper was read by Principal Dawson. It contained a minute stratigraphical description of the Devonian rocks of the vicinity of St. John, and of the overlying carboniferous and new red sandstone deposits. A very interesting fact was the occurrence in these beds, of successive floras of the Devonian, lower carboniferous, coal-formation, and mesozoic periods, all more or less distinct from each other.

Mr. Leeming stated that Mr. Whiteaves would enter on his duties as scientific Curator to the Society on Wednesday, 1st April, and after that date would be found at the rooms.

PROCEEDINGS OF THE ANNUAL MEETING.

The annual meeting of this Society was held in their rooms on the evening of May 18th, Principal Dawson, one of the Vice-Presidents, in the chair. A large number of the members were present. Mr. J. F. Whiteaves, the Scientific Curator, on behalf of the recording secretary, Mr. John Leeming, read the minutes of the last annual meeting; after which the usual annual address of the presiding officer was read, as follows:—

THE PRESIDENT'S ADDRESS.

Gentlemen—I could have wished that the duty of preparing the annual address of the President had, on the present occasion, fallen on some other person, as I fear that the pressure of various official duties has scarcely left me time to do justice either to myself, or to the work of the Society—still less to enter on that wider survey of the progress of Natural Science to which we are invited on an occasion of this kind.

I find that, in the past winter, twenty-six original papers have been read at the meetings of the Society, in addition to a number of articles and reviews contributed by our members, and published in the *Naturalist*, without being formally read here. I shall not give a list of these papers, but shall endeavour to group them according to the subjects to which they relate, and to give in this way a general sketch, first of the amount of original scientific research represented by these papers; and secondly, of their bearing on the arts of life, and on the material improvement of this country.

To begin with Geology, which in our day sits justly enthroned as queen of all the natural history sciences, and with Canadian Geology which most nearly concerns us, we have had several elaborate papers on those ancient, disturbed, disputed, and until lately problematical rocks on which the oldest capital of Canada stands, and which are consequently known to our survey as the "Quebec group." To the common eye, the ancient citadel of Quebec has been standing impregnable and secure, but in the minds of geologists it has been floating like a mirage, now here and now there, until many men have been at a loss in what terms to express their idea of its geological place. The officers of our survey have addressed themselves with much zeal and success to this formation, and deserve great credit, first for frankly giving up incorrect views previously maintained; and secondly, for establishing the true geological position of these difficult rocks on a sure basis. Mr. Billings has in the past year furnished us with an interesting view of the parallelism of these beds with the Llandeilo of England. Sir Wm. E. Logan has introduced to us a new and useful laborer on these fossils, Mr. Devine, of Quebec, and will himself publish in next number of our proceedings an elaborate survey of the stratigraphical arrangements of the beds at Point Lévi. In the geology and mineralogy of the metalliferous deposits of this group, as they exist at the celebrated copper mine of Acton

Mr. MacFarlane's paper is a great step in advance, more especially in the large number of facts which he chronicles, and which, but for his careful collection of them in the progress of the workings, would have been forever lost.

Making a sudden leap from these ancient rocks to the most modern formations, our proceedings show several valuable contributions to the geology of the post-pliocene deposits. In this field, Mr. Billings' paper on the remains of fossil elephants found in Canada is of especial value, as for the first time giving accurate descriptions and figures of these remains, and identifying our species with that known to American naturalists as *Elephas Jacksoni.* In this paper, Mr. Billings has worthily followed up, with reference to the extinct elephantine animals of Canada, the able investigations of Dr. Falconer on the general distribution of these animals. The society has also received valuable contributions in the field of Canadian post-tertiary geology from Mr. Robb, Mr. Bell, and Mr. Whiteaves. We have not yet succeeded in Canada in tracing man back to the post-pliocene period, as is claimed to have been done in Europe; but, as I have pointed out in papers on this subject, read before the society on former occasions, the researches in the superficial geology of Canada, will have important bearings on many disputed questions as to the distribution and supposed changes of plants and animals which have survived from the post-pliocene to the modern period.

On points of the geology of the United States connected with Canadian geology, we have had important contributions from Prof. Hall and Col. Jewett. The paper of the late lamented Moses Perley on Newfoundland, presents a valuable picture of the geology and topography of that island; and the paper of Mr. Matthews on the geology of St. Johns, New Brunswick, is an excellent piece of stratigraphical geology, bearing on the solution of some most important and difficult questions. In this connection I shall take the liberty to apologise for the great length to which my own papers on the Reptiles of the coal period have extended, and to mention the ray of light which the footprints of the modern King-crab have enabled me to throw on the *Protichnites* of the Potsdam sandstone.

In chemical and economical geology, I need merely mention the profound generalisations of Dr. Hunt in his paper on the chemistry of the earth; the practical information contained in the same author's paper on the gold-fields of Canada, and in that by Mr. MacFarlane on the extraction of cobalt from Canadian ores.

In zoology and botany, our work has perhaps been less extensive and important than in geology. In these fields, however, we may mention Dr. Lawson's paper on *Aphis avenæ;* Mr. Cooper's on *Saperda Candida;* Mr. Scudder's on the *Orthoptera* of the northwest territory; Dr. Cobbold on a Canadian *Tænia;* Mr. Billings on *Monohammus;* Mr. Whiteaves on the land and fresh-water shells of Canada; Prof. Bailey on the *Diatoms* of the St. John River; Mr. Barnston on the Otters of America; and the completion of Dr. Hall's elaborate paper on the mammalia and birds of Montreal.

All of these papers contain important new facts in natural history. One of them, that of Mr. Whiteaves, nearly exhausts the subject to which it refers, in so far as present material is concerned; others add new species of the Canadian fauna; and several are of great practical value.

In their purely scientific aspect, the pursuits of the *Naturalist* should be highly esteemed, as widening our views of nature, enlarging our minds, and elevating the reputation of our country. They are, however, also of utility to the country in their economical applications. To this I would especially advert, in connection with our proceedings, as establishing a valid claim to consideration on the part of the public, independently of our merely scientific discoveries, or of the pleasure to be derived from our collections and lectures.

In 1862, Mr. Macfarlane of Acton gave us the results of experiments on certain varieties of iron pyrites occurring near Brockville, from which he showed that cobalt and sulphuric acid could be obtained in remunerative quantities. These experiments seem to have led him to further studies of the reactions of sulphuret of iron and common salt; and the result has been another paper, detailing a new mode of obtaining chlorine and soda, which has been patented in England, and promises to effect a revolution in the manufacture of these important substances, and to cheapen and render more accessible some of the most useful agents in the promotion of comfort, cleanliness and health.

A little striped beetle, *Saperda Candida*, burrows when in its larval condition in our apple trees, and soon blasts the results of much expenditure, and of years of labour. Mr. Cooper of Quebec has shown us how the entomologist, by careful study of this creature's habits, can counteract its operations, and enable us to enjoy some degree of immunity from its ravages. Mr. Billings has explained to us the habits of another insect destroyer, of the genus *Monohammus*, which it seems can devour in a single season and on a single property, pine timber to the value of £10,000. Dr. Lawson has laid before us the habits of the curious little *Aphis*, which sometimes swarms in our grain fields; and has to some extent vindicated it from the charges brought against it, and which more properly lie at the door of the wheat midge. I have myself only been prevented by lack of time from bringing under your notice some sketches of the habits of the Army-worm, and of some other of the more common insect pests, and may commend the subject to other observers as a most promising and valuable field of labor.

A committee of our society has been engaged in promoting measures for the more effectual protection of the smaller insectivorous birds, to which has been assigned by Providence the function of protecting us against insect ravages, and which, as a part of the unpaid police of nature, as well as for their beauty and their song, should be cherished and guarded from harm in every country truly civilized.

Another Committee has been engaged in the investigation of the causes of the decay of the apple orchards, for which the island of Montreal was once celebrated. Among the principal results of this inquiry, in addition to points well known to gardeners, may be mentioned the following:—(1) That old varieties of trees necessarily become delicate and unproductive, and should be replaced by new and hardy seedling varieties. (2.) That efforts should be made to supply to the soil the mineral matters required to constitute the ashes of healthy wood, and which in the process of culture become exhausted. (3.) That the habits of injurious insects, fungi, &c., should be carefully studied, and that the birds frequenting orchards should be more effectually protected.

Other kinds of trees have also attracted our attention, and among these the vine, which, notwithstanding the great success of its culture in vineries, and the zealous efforts of M. DeCourtenay, is not yet extensively cultivated in the open air. Observation and experience have convinced me that wherever, even in Lower

Canada, there are gravelly or light soils, or stony hill-sides, with good exposure, some of the varieties of our native grapes could be ripened abundantly. Independently altogether of the manufacture of wine, the introduction of the grape as an article of food of a peculiarly agreeable and healthful quality, is well deserving of effort.

At some of our meetings discussions have arisen respecting the use of Canadian fibres in the manufacture of fabrics and of paper. It would seem that the fibres of the stem and the silky coma of the seed of our common milk-weed, might be made available in this way, and that the culture of the plant might be profitably undertaken. A more important subject, perhaps, is the culture of silk. Efforts are now being made by the Botanical Society of Kingston, to introduce into this country from China, a species of silk-worm, *Bombyx Cynthia*, said to be hardy, and which feeds on the leaves of *Ailanthus glandulosa*, a well-known ornamental plant, rather tender for this climate, but still capable of cultivation here. Dr. Lawson has kindly sent me a few of the cocoons, from which it is hoped that a small colony of the animals may be reared, as Mr. Sheppard of this city possesses a little plantation of the *Ailanthus*. Dr. Lawson has also furnished for publication a valuable paper on the subject, by Mr. Patterson of Leith. It appears to me, however, that the silk of some of our native moths might be rendered more available than that of any foreign species. The ubiquitous moths of the genus *Clisio campa*, which devastate our forests and orchards, produce delicate silken cocoons, tons of which go to waste annually, and the amount could no doubt be greatly increased by the artificial culture of the animal. A still more abundant source of silk would be the cocoons of the great emperor moths of the genus *Attacus*, some of which, and especially the *A. cecropia*, yield cocoons superior to those of many of the species cultivated in China and India. Harris, in his "Insects of Massachusetts," states that the silk of this moth is very strong and quite available for manufacture. The writer of an excellent article on this subject in the Journal of the Board of Arts and Manufactures for Upper Canada, adduces additional facts as to the easy breeding and culture of the moth. An esteemed correspondent and good entomologist, Dr. Morris of Baltimore, has naturalized there the *Ailanthus* moth, and is now engaged in experiments on the culture of the American species. There seems no reason why these creatures, instead of reducing our forests and orchards to nakedness, might not be employed in clothing the daughters of Canada with fabrics equal to those of China and India, and in adding silk to our articles of export. In effecting this result, the naturalists must, in the first instance at least, take the lead.

An important part of the work of this society is that of popularizing natural science, in such a way that its results may be extensively known, and that new votaries may be attracted to its study. This end we seek to attain by our popular course of Somerville lectures, free to the public, and by throwing our museum open on easy terms. I should especially mention in this connection, the engagement of our scientific Curator, Mr. Whiteaves, under whose care large portions of our collections are being arranged in such a manner as to give education in natural history to any ordinary observer, and to aid the labours of the scientific student.

We are also reminded, in glancing at the proceedings of the past year, that we do not now labour alone. On one side, the Canadian Institute of Toronto, and on the other the Literary and Historical Society of Quebec are pursuing similar paths. The young but vigorous Botanical Society of Canada, established at Kingston, has availed itself of our journal for the publication of some of its papers and proceedings. The Natural History Society of New Brunswick has in like manner contributed some important memoirs for publication. The Literary and Scientific Society of Nova Scotia has sent us its constitution and regulations. Our proceedings have been enriched by valuable contributions from Rupert's Land, and there is now a natural history society in that region. Mr. Bethune has given us a catalogue of Canadian entomologists, and this has been followed by the organization in Toronto of an Entomological society. We have also to express our thanks to many individual contributors and correspondents in various parts of British America, and to many scientific institutions and associations abroad, which have in various ways recognized our humble labors. More especially in this regard should we state our obligations to the Smithsonian Institution of Washington for its frequent kindly offices. The society has further to congratulate itself that its relations with its two nearest neighbors—the Geological Survey of Canada and the McGill University—are at once intimate and mutually advantageous. The officers of the survey are among our most valued members, while through us they are sometimes enabled more readily to bring under the public notice important facts or discoveries. The prosperity of this society is an important stimulus to the study of natural science in the university; and, on the other hand, the graduates who are constantly going forth with a knowledge of the elements of natural science, and some degree of taste for its cultivation, must materially strengthen the society.

The Council will report to the Society a regulation for the disposal annually of a silver or bronze medal to some gentleman distinguished for important services to science, and especially to science in Canada. I have further very much pleasure in stating that it is proposed that the first silver medal granted under this regulation shall be bestowed on Daniel Wilson, LL.D., of University College, Toronto. Dr. Wilson came to Canada with a high reputation, earned in the study of British archæology; and in this country he has pursued with much energy and success researches in the ethnology and antiquities of America, the results of which have appeared in many papers, published here and abroad, and more recently in his valuable work "Pre-historic Man." It is one of the most pleasant features connected with the institution of these medals, that they will thus enable us to testify our appreciation of the services of labourers in science not of our own body, nor resident here, but who are nevertheless fellow-workers with us in the objects which we have in view.

I have reached the limits to which an address of this kind should be restricted, without exhausting the topics suggested by our annual meeting, and perhaps without having noticed some important parts of our work; but I must now conclude, with the expression of the hope that the coming year may be still more prosperous than the last, and more fruitful of great results.

Report of the Council.

The Council of the Natural History Society of Montreal, on the occasion of the 35th Annual Meeting of the Society, find it their duty to submit to the members generally a review of the proceedings and condition of the Society during the past year. And if their predecessors have had cause on former occasions to congratulate themselves on the steady progress of the Society, your Council have now the pleasure of announcing that no other year has excelled, or perhaps equalled, the one just closing in its history, either for the amount of scientific work done, or for the successful introduction of new valuable features, which it is believed will be sources of permanent benefit to the Society. Among these, two may be especially mentioned: first, the commencement of a series of annual social meetings open to the public; and secondly, the appointment of a scientific curator, a want which had grown into a reproach to the Society. It is deemed proper to exhibit the operations and progress of the Society under appropriate heads. And first of

THE MUSEUM.

During the past year the donations to the Museum have been more than ordinarily numerous and valuable. Without desiring to be invidious, your Council cannot but acknowledge the extreme liberality of some members of the Society who have very handsomely added to departments hitherto scarcely represented in the Museum. Through the kindness of Sir William Logan, the curator has been enabled to add to our collection some seventy-two specimens of marine shells, eighty-one of land and fresh water shells, ten echinodermata (sea urchins, and star-fishes), four crustaceans, four cirripides, six annelidæ, in all 177 species, besides a number of bryozoa and sponges, nearly all new to science. Dr. Dawson, among many other valuable gifts, presented the Society several species of marine shells, echinodermata, &c., from the gulf of St. Lawrence, Labrador, Nova Scotia, and the United States. James Ferrier, jun., Esq., has presented a most extensive and valuable series of foreign shells, in which the Society's collection was formerly very deficient. The number of species is about 410, and contains many rare genera. R. J. Fowler, Esq., has kindly enabled the Society to complete its collection of land and fresh water shells of Lower Canada, by contributing the missing species. Your Council invite an inspection of these valuable additions to the Museum, and trust that the considerate liberality of the donors may be imitated by others. Your Council regret that the number of quadrupeds is still so very small. They have, however, issued a circular inviting contributions to their mammalia, and adding a list of the specimens wanted. Of this circular one thousand copies were printed, distributed to each member, and extensively sent to kindred societies in Europe and the United States; so that your Council are sanguine the Society will soon be enabled to see some improvement in this department. Some interesting specimens have been added to the collection of birds. Mainly through the zeal of Mr. Whiteaves, the curator of the

Society, a commencement has been made for a collection of the eggs of North American birds, and several donations have already been received. Your Council having authorized Mr. Hunter the janitor of the Society, to collect specimens of the fish of this country not in the Museum, a very creditable progress has been made in the work, which it is earnestly hoped will be further promoted by the members. In the miscellaneous department various contributions have been received; and your Council have had the pleasure of welcoming among the donors a new and promising organization—the Numismatic Society of Montreal. Your Council would offer as a suggestion to their successors the consideration of the expediency of uniting the Society's collection of coins with that of the new Society.

THE LIBRARY.

The additions to the library have consisted of donations from members and scientific societies, or exchanges of "the Naturalist," the financial state of the Society still forbidding the purchase of scientific works much wanted.

APPOINTMENT OF A SCIENTIFIC CURATOR.

One of the greatest difficulties with which the student of Natural History in Montreal has had to contend, was the impossibility of finding a trustworthy classified collection, especially in zoology. It were needless to remind the members, of the chaotic state in which the collection of this Society has been permitted to remain. And although a former sub-curator and some members had bestowed much time on the task of classification, still, all must be aware that the work required to be done could not possibly be effected by a few spasmodic efforts of individuals, having but little leisure to spare. Your Council therefore esteem it matter of much congratulation that they have been enabled to secure the valuable and zealous services of one so well and so favourably known as Mr. J. F. Whiteaves. It cannot be expected that all his labours should be specified within the limits of this portion of the Report; but your Council would beg leave to refer to the statements already made public, to Mr. Whiteaves' Report delivered last month, and finally to the Museum itself, where the members can judge for themselves, as to the expediency and necessity of the appointment.

ORIGINAL PAPERS READ.

In the past session, twenty-six original papers in the departments of zoology, geology, botany, and ethnology have been read, the value and importance of which may be estimated by reference to "the Canadian Naturalist," in which they have nearly all been published. Many of them have been noticed in terms of the highest eulogy in the scientific periodicals of Europe and the United States.

The Publication of the Naturalist.

This Journal has been continued as heretofore; and the former liberality of its publishers, Messrs. Dawson Bros., has been exceeded during the past year, they having furnished its columns with an unlimited number of engravings at a considerable pecuniary loss. The volume for 1862 (the 7th) has been duly completed. Two numbers for 1863 have been issued, and the third is in progress. It is intended to commence a new series after the present volume is completed, with Scotch paper, expressly made for the Journal, and new type. Its circulation however is still much smaller than it should be, and it is hoped members will use due efforts to extend it.

Public Lectures.

The annual Somerville course of public lectures was delivered, as usual, and was well attended. The following is an enumeration of the lecturers and subjects discussed:

12th February, 1863.—First lecture, Dr. Dawson, On some novelties in Natural History.

19th February.—Second lecture, Mr. Rimmer, On the Fishes of the St. Lawrence.

26th February.—Third lecture, Mr. Robb, On the Rocks, Woods, and Waters of Western Canada.

5th March.—Fourth lecture, Mr. Gilbert, On the Climate and Products of Australia, and the Customs of the Inhabitants thereof.

12th March.—Fifth lecture, Professor Small, On the Natural History of the Old World compared with that of the New.

19th March.—Last lecture, Mr. Leeming, A Glance at Science as a Recreation.

Conversazione.

On the evening of the 3rd of February the first Annual Conversazione of the Society was held. The rooms had been provided with a large collection of works of art, microscopes, &c., by the friends of the Society, and addresses were delivered by Principal Dawson, the Rev. A. F. Kemp, and the Rev. Dr. De Sola. The audience was the largest that had ever assembled in the city of Montreal for such a purpose; and your Council have great pleasure in believing that the experiment proved a decided success. The tendency of such social reunions must necessarily be beneficial to the Society; opportunity being afforded for general participation in the discussion of subjects connected with natural science.

Botanic Garden.

Your Council deemed it proper to appoint a committee* to co-operate with the Montreal Agri-Horticultural Society for the purpose of establishing a Botanic Garden in this city, if possible in the grounds of the McGill College. Your Council are happy to state that the project has been most favourably received by the public; and the governors of McGill University having, in the same spirit of liberality which led them to present gratuitously the site of the Society's present building, offered their grounds at a nominal rent for the purposes of the garden, your Council trust that so important an auxiliary to this Society may soon be established.

Miscellaneous.

Your Council are happy to announce a continued increase in the number of members. During the month of July his Excellency the Governor General visited the Museum, when an address was presented to him requesting him to become a patron of the Society. His Excellency was pleased to assent and to express great gratification with the appearance of the Museum. The number of additional ordinary members has been forty-eight, corresponding members nine, and life members two, in all fifty-nine. Your Council believe fully one half of these resulted from the favourable impression made by the Society's Conversazione, and they know that one other result was that a member liberally offered to commence a list with the sum of $200, to pay off the remaining indebtedness of the Society. In this connection also your council deem it fitting to refer to the liberality of the Society's treasurer, James Ferrier, jun., Esq., who to save the payment of a high rate of interest, has advanced a considerable sum of money for the purpose of liquidating the Society's indebtedness. The usual government grant was received—an earnest, your Council trust, that the legislature will continue to appreciate the efforts of the Society and enable them to bring together the means by which scientific attainments can be acquired. As evincing their own desire and that of the Society's to extend as widely as possible the knowledge of natural science, your Council granted the use of their rooms to Mr. Denton during the month of October for the delivery of a course of five lectures on geology, being desirous more particularly that the younger and non-scientific portion of the community should benefit by them, and devote more attention to such subjects than they have been accustomed to give. Among other proceedings of the year, your Council would further report that a committee was appointed to prepare for a field day under the direction of the Society, but that it was found necessary to postpone it for a future occasion; that the services of an assistant secretary have been dispensed with; that the building and portico have been repainted, and the sign which has been placed thereon, has had the effect of increasing the number of visitors; that the Society's amended act has been printed, and that the election o additional members of Council under its provisions has been found to promote the efficiency of its operations; that correspondence has been opened with kindred societies occupying a very high place in European estimation, among them the "Société d'Histoire Naturelle et de Physique" of Geneva; and that these societies have come to look upon the organ of the N. H. Society, "the Canadian Naturalist," as one of the most valuable exponents of the scientific progress of this continent. The sympathy of societies and individuals with the aims of the Natural History Society of Montreal, has been shown by many generous donations both of books and specimens; but your Council would offer as a suggestion that many desirable objects, the products of foreign countries, might be obtained by enlisting in behalf of the Society the assistance of the masters of the various vessels trading to this port, who have so many opportunities of procuring valuable specimens, and who have so extensively benefitted the various collections in the United States. The senior members of the Society will gratefully remember the liberal and numerous contributions of their zealous friend Captain Stoddard, whilom of the ship "Thames."

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* The committee consisted of Rev. Dr. De Sola (Convener), Rev. A F. Kemp, Messrs. S. C. Bagg, C. Robb, and John Leeming.

Your Council would especially record its gratification at the very efficient manner in which Mr. Wm. Hunter has discharged the duties of his office, combined as it has been with an obliging demeanor on all occasions.

A committee, appointed by the Council of the Natural History Society, at their meeting of the 23rd inst., to consider what disposition should be made of the medals of the Society, reported that after due consideration they would recommend that at least one bronze medal should be voted annually by the Society to some resident in the British provinces distinguished for attainments in natural science, or for special discoveries or active engagement in the same; and that the *silver* medals of the Society be presented *occasionally* to the same class of persons, whether resident in the British provinces or not.

The Council would now propose to the Society that the silver medal of the Society for the present year be given to Professor Daniel Wilson, LL.D., of Toronto, in acknowledgment of his services in American ethnology.

And now your Council would divest themselves of the trust with which they have been honoured, with the fervent hope that the onward steps taken during the past year may be continued and extended in the future, and that each succeeding anniversary meeting may witness an increase of prosperity and usefulness in the Natural History Society of Montreal.

Abraham De Sola, LL.D.,
Chairman of Councu.

Montreal, May 18th, 1863.

REPORT OF THE SCIENTIFIC CURATOR.

It should be observed that this report refers to a period of time little exceeding six weeks, from the 1st of April, 1863, to the 18th of May in the same year. On entering upon my duties one of the first things that struck me was the want of arrangement of the specimens in the side cases in the gallery. These contained a confused assemblage of marine shells, Echinodermata (sea urchins, star fishes, etc.), Crustaceans (crabs, lobsters, etc.), Sponges and other marine organisms from the Gulf of the St. Lawrence, and a large series of the land and fresh water shells of Upper and Lower Canada. These were the property of the Geological Survey of Canada, and were collected principally by Messrs. J. Richardson and R. Bell. The cases containing the same, also belonged to the Geological Survey. After several interviews with Sir W. E. Logan, I was requested to go over the whole of this rather large collection and pick out as complete a series as possible, for the Natural History Society. Since that time I have carefully mounted, classified and named the collection thus formed, which will now be available for reference and study.

The sponges, corallines, and other undetermined and, for the most part, minute objects have been temporarily grouped together in one case by themselves. The following is a rough estimate of this collection:

	No. of Species.
Marine Shells, (from the lower St. Lawrence)	72
Land and Fresh Water Shells	81
Bryozoa, (Sea mats, etc.)	undetermined.
Echinodermata, (Sea urchins, star fishes etc)	10
Crustacea	4
Cirripedes, (barnacles, etc.)	4
Annelida, (marine worms, inhabiting, in this case, shelly tubes.)	6
Sponges, (mostly species new to science.)	undetermined.

It should be stated that the tablets upon which these specimens are affixed were presented by the Geological Survey.

Among the marine shells are three species: Crenella nigra, Gray; Trochus occidentalis, Mighels; and Margarita obscura, Gould; which had previously been omitted in the lists of shells inhabiting the Gulf of St. Lawrence as published in the "Canadian Naturalist."

Dr. Dawson has presented to the Society several species of marine shells, echinodermata etc., from Gaspé, Labrador, Nova Scotia, and the United States. Among them is the common edible periwinkle of Europe (Littorina littorea) discovered by Dr. Dawson at Pictou, Nova Scotia, where it is believed to have been for the first time detected on the North American continent.

Mr. R. J. Fowler has presented a series of specimens of eighteen species of those Lower Canadian land and fresh-water shells which were wanting to complete the Society's local collection. Some of these are rare species, for the first time described as inhabiting Lower Canada, in the April Number of the "Canadian Naturalist" for 1863. The specimens of the above mentioned series have been carefully arranged and named, with the donor's name attached to each species.

Mr. James Ferrier, Jun., has presented to the Society a most extensive and valuable series of foreign shells, including several rare and interesting genera. The number of species is as follows:

From the Bay of Mazatlan, Mexico:

Bivalves, 30 species. Univalves, 57.

Exclusive of these

Bivalves, 87 species. Univalves, 228.

These have been mounted, named, and classified. The general collection of shells belonging to the Society has also been partly classified and arranged. The following is an estimate of the Society's collection of shells, previous to the above mentioned donations:

Bivalves,	74 species.
Univalves,	340 "

As far as possible the names of the donors have been given with the name of each species, but in some cases this could not be ascertained.

To add to the interest of the Society's collection of birds, an attempt has been made to get up a collection of the eggs of North American birds. A few gentlemen have been seen, and the following donations received:

From J. Ferrier, Jun., Esq.,
  15 species of eggs from Canada and the United States.
From G. Barnston Esq.,
  6 species of eggs from the Hon. Hudson Bay Company.
  1 " egg from Lake Superior.

The eggs thus obtained have been named and carefully put away, until a proper cabinet be voted by the Society for their reception.

Prof. Baird, of the Smithsonian Institute at Washington, has been written to by me soliciting donations to this branch of our natural history.

As Recording Secretary to the Society, I have endeavoured to make the newspaper reports of our ordinary and annual meetings more accurate and satisfactory. In my spare time I have attempted to call some attention, through the press, to what the Society is endeavouring to effect, by reviewing its journal and by popular articles on local natural history. It has been my duty too, assisted by other members of the Society, to prepare the annual report for the year ending May 17th, 1863. Finally, it is hoped that reasonable courtesy and attention has been paid to visitors who have wished for any special information, and to strangers.

J. Whiteaves F. G. S.,
Honorary Member of the Ashmolean
Society, Oxford, England, etc.,
Scientific Curator and Recording Secretary.

It was moved by Dr. David, seconded by Professor Cornish:—That the various reports now presented be accepted, and with the annual address printed as usual.

After which a vote of thanks to the officers of the past year was proposed by Mr. Mackay, seconded by Major Latour, and unanimously carried.

The Society then proceeded to ballot for officers for the ensuing year, when the following were duly elected.

OFFICERS FOR 1863-64.

President.—Principal Dawson, LL.D., F.R.S., &c., &c.

Vice-Presidents.—The Lord Bishop of Montreal; Rev. A. De Sola, LL.D.; Sir W. E. Logan, LL.D., F.R.S., &c.; T. Sterry Hunt, M.A., F.R.S., &c.,; Rev. A. F. Kemp, M.A.,; E. Billings, Esq., F.G.S.,; J. Leeming, Esq., and W. H. A. Davies, Esq.

Treasurer.—J. Ferrier, jun., Esq.

Cor. Secretary.—Prof. P. J. Darey.

Rec. Secretary aud Scientific Curator.—J. F. Whiteaves, Esq., F.G.S., &c.

Librarian.—Mr. H. Rose.

Council.—Dr. Smallwood; Stanley C. Bagg, Esq.; A. Rimmer, Esq.; C. Robb, Esq., C.E.; E. Murphy, Esq.; D. A. P. Watt, Esq.; Dr. Hingston; J. H. Joseph, Esq., and J. Swanston, Esq.

Library Committee.—Messrs. J. C. Becket; Prof. Cornish; Dr. Fenwick; Dr. David, and Dr. Mackay.

Editing Committee of the "Canadian Naturalist."—D. A. Poe Watt, Esq., Acting Editor; Dr. Dawson; Dr. Hunt; E. Billings, Esq.; Rev. A. F. Kemp, M.A.; Prof. Robins, and the Corresponding and Recording Secretaries.

The Canadian Naturalist.

The *Canadian Naturalist* is sent to the following Institutions and Societies :—

CANADA, ETC,

University College,	Toronto.
Trinity College,	Toronto.
Canadian Institute,	Toronto.
Knox's College,	Toronto.
Victoria College,	Cobourg.
Queen's College,	Kingston.
Botanical Society,	Kingston.
McGill College,	Montreal.
Bishop's College,	Lennoxville.
Laval University,	Quebec.
Literary and Historical Society,	Quebec.
Natural History Society,	St. John, N. B.

UNITED STATES.

Harvard College,	Cambridge, Mass.
Amherst College,	Amherst, Mass.
Yale College,	New Haven, Conn.
Natural History Society,	Boston, Mass.
State Library,	Albany, New York.
Albany Institute,	Albany, New York.
Essex Institute,	Salem, Mass.
Lyceum of Natural History,	New York.
Astor Library,	New York.
Academy of Natural Sciences,	Philadelphia.
Franklin Institute,	Philadelphia.
Smithsonian Institute,	Washington.
Academy of Science,	St. Louis, Missouri.
University of Nashville,	Tennessee.

GREAT BRITAIN.

Geological Society,	London.
Linnæan Society,	London.
Royal Society,	London.
Royal Geographical Society,	London.
British Museum Library,	London.
University College,	London.

Society of Arts,	London.
Geological Survey of Great Britain,	London.
Geological Society,	Dublin.
Royal Dublin Society,	Dublin.
Literary and Philosophical Society,	Manchester.
Natural History Society,	Newcastle upon Tyne.
Bodleian Library,	Oxford.
University Library,	Cambridge.
University Library,	Edinburgh, Scotland.
University Library,	Glasgow, Scotland.
University Library,	St. Andrew's Scotland.
College Library,	Maynooth, Ireland.
Queen's College,	Cork, Ireland.
Queen's College,	Belfast, Ireland.

CONTINENT OF EUROPE.

Société Géologique de France,	Paris, France.
Académie des Sciences,	Paris, France.
Academia Car. Leop.,	Jena, Saxe Weimar.
Imper. Geological Institute,	Vienna, Austria.
Deutsches Geolog. Gesellschafft,	Berlin, Prussia.
Société Hollandaise des Sciences,	Haarlem, Holland.
Konigl. Sachs. Gesellschaft der Wissenschaften,	Leipzig, Saxony.
Société Impériale des Naturalistes,	Moscow, Russia.
Konigl. Bayerischen Akademie der Wissenschaften,	Munich, Bavaria.
Stockholm Biksbiblioleket,	Stockholm, Sweden.
Upsala University,	Upsala, Sweden.
Academy of Sciences,	Stockholm, Sweden.
Christiania University,	Christiania, Norway.
Royal Library,	Copenhagen, Denmark.
St. Petersburg, Bibliothèque Impériale,	St. Petersburg, Russia.
Dorpat University,	Dorpat, Russia.
Kasan University,	Kasan, Russia.
Helsingfors University,	Helsingfors, Russia.
Amsterdam Stadsch Bibliotheck,	Amsterdam, Holland.
Leyden Batavian Academy,	Leyden, Holland.
Gröningen University,	Gröningen, Holland.
Bonn University	Bonn, Prussia.
Breslau University,	Breslau, Prussia,
Freiberg Royal Acad.,	Freiberg, Saxony.

And to the following Periodicals :—

CANADA.

Journal of the Board of Arts,.........Toronto.

UNITED STATES.

Silliman's Journal,..................New Haven.

GREAT BRITAIN.

Annals and Magazine of Natural History,..London.
The Geologist,......................London.
The Phytologist,....................London.
The Zoologist,......................London.
Journal of Botany,..................London.
The Technologist,...................London.
London, E. and D. Philosophical Magazine, London.
Edinburgh New Philosophical Journal,...Edinburgh.

CONTINENT OF EUROPE.

Annales des Sciences Naturelles,........Paris, France.
Allgemeine Deutsches Naturh. Zeitung,..Dresden, Saxony.
Archiv. fur Naturgeschichte by Weigman,.Berlin, Prussia.
Leopoldoia,..........................Jena, Saxe Weimar.
Leonhard und Brohn Jahrbuch,........Stutgardt, Wurtemburg.

LIST OF DONATIONS TO THE MUSEUM.

DONORS' NAMES.	DONATIONS.
	May 26th, 1862.
— Lambe, Esq.	English silver two-penny piece.
Dr. A. H. Hall,	Skin of Star nosed mole, (*Condylura cristata, Linnæus.*)
Miss Wright,	Hen's egg within another.
B. Hall, Esq.,	Two eggs joined together.
N. Macintosh, Esq.,	Lop eared Rabbit.
Mr. W. Hunter,	Little Sandpiper, female, (*Tringa pusilla, Wilson*)
J. Ferrier, Jr., Esq.	Number of small Fish and water plants for the Aquaria.
Mrs. A. Miller,	Specimen of Copper Ore from Lake Superior
Mr. R. P. Isaacson,	Antler from the Cape of Good Hope.
Mr. W. Hunter,	Muscicapa—? (*Flycatcher, species undetermined.*)
	June 30th, 1862.
— Ramsay, Esq.,	4 Eggs of the spotted Sandpiper, (*Tringoides macularius, Gray.*)
Mr. W. Hunter,	Geothylypis Philadelphia, Baird, male. (*Mourning warbler.*)
	Dendroica Striata, Baird, female. (*Blackpoll warbler.*)
	Helminthophaga ruficapilla, Baird, male. (*Nashville swamp warbler.*)
	Mniotilta varia, Viellot, male. (*Black and white creeper.*)
	Vireosylvia —? species undetermined.
J. Ferrier, Jr., Esq.	Fish and aquatic insects for the Aquaria.
	August 25th, 1862.
— Ross, Esq.	Double hen's egg, grown together.
Mrs. McIntosh,	Lop-eared rabbit in spirits.
G. Barnston, Esq.,	Pelicanus erythrorynchus, Gmelin, (*American Pelican.*)
	Accipenser carbonaria, Agassiz, (*Long nosed Sturgeon.*)
	Salmo fontinalis, Linnæus, (*Brook Trout.*)
	Coregonus Artedi, (*Fresh water "Herring."*)
	Coregonus sapidissimus, (*White fish.*)
	Lota maculosa, Lesuer, (*Loche.*)
Dr. Dawson,	4 Limulus Polyphemus, Latreille, (*King Crab.*)
Mrs. Hamilton,	An antique pair of stays, 100 years old.
Mr. Higgins, Côte S. Paul	Petrifaction, (*Incrustation of carbonate of lime and oxide of iron around leaves and branches.*)

LIST OF DONATIONS TO THE MUSEUM.

DONORS' NAME.	DONATIONS.	
	September 29th.	
Mrs. Peter Redpath, ...	4 young Limulus Polyphemus, Latreille. (*King Crab.*)	
J. Ferrier, Jr., Esq., ...	9 Gold fish and several Eels for the Aquaria.	
H. G. Vennor, Esq., ...	Salmo "namycush" Pennant. The Longe. Lake Magog, Georgeville.	
C. F. Hill, Esq..........	Hen's egg of unusual size.	
D. McKay, Esq.,.........	3 Flint arrow-heads from Burlington heights.	
A. Rimmer, Esq.,........	2 specimens of Gorgonia —? (*Sea fan.*)	
Mr. W. Hunter, ...	W. Cowper, Esq., specimens of Saperda candida.	
	Perisoreus Canadensis Bonaparte. (*Canada jay.*)	
	Eggs of Emys picta. (*The painted turtle.*)	
	Case containing 18 species of Fish from the St. Lawrence at Montreal, as follows:	
	1 Perca flavescens, Mitchell. (*Common yellow Perch.*)	
	1 Labrax lineatus, Bloch. (*Striped Bass.*)	
	2 Lucioperca Americana, Cuvier and Valenciennes. (*American Pike Perch.*)	
	1 Centrarchus œneus, Lesuer. (*Rock Bass.*)	
	2 " fasciatus, Lesuer. (*Black Bass.*)	
	1 Pomotis vulgaris, Richardson. (*Sun fish*).	
	2 Gasterosteus —? (*Stickleback, species undetermined.*)	
	1 Pimelodus catus ? Linnæus. (*Common Cat fish.*)	
	1 Catastomus —? (*Sucker, species uncertain.*)	
	1 Leuciscus pulchellus, Storer. (*The "Roach Dace"*).	
	Esox estor, Lesuer. (*Common Pike or Maskinonge.*)	
	1 Coregonus albus, Lesuer. (*White fish.*)	
	1 Hyodon clodalis, Lesuer. (*Winter shad.*)	
	2 Lepidosteus oxyurus. (*Gar pike.*)	
	1 Lota maculosa, Lesuer. (*Common ling.*)	
	1 Anguilla tennirostris, DeKay. (*Common Eel.*)	
	1 Accipenser oxyrynchus, Mitchell. (*Sharp nosed Sturgeon.*)	
	1 Pteromyzon nigricans ? Lesuer. (*Blue Lamprey.*)	
	Also Amia ocellicauda, Richardson. (*The Mud or Beaver fish, from Lake St. Peter.*	
	October 27th, 1862.	
J. Ferrier, Jr, Esq.,.....	Fishes for the Aquaria.	
G. Barnston, Esq.,......	2 Salmo "siscowet," Agassiz.	From Lake Superior.
	1 Salmo ursinus, Barnston, nov. sp.	
	1 Salmo amethystinus ? Mitchell.	
	1 Salmo Hoodii, or nov. sp. (*S. Bairdii, Barnston, M. S. S.*)	
	1 Young beaver, (*Castor fiber.*)	

LIST OF DONATIONS TO THE MUSEUM.

DONORS' NAME.	DONATIONS.
	October 27th, 1862. (*Continued.*)
Dr. Van Courtlandt,....	Specimens of Gasterosteus gymnetes? and Leuciscus, new species.
Mr. W. Hunter, ...	Picoides hirsutus, Gray. (*Banded 3 toed Woodpecker.*)
	November 24th, 1862.
P. Macfarlane, Esq.,.....	Minerals from the Giants Causeway.
J. Ferrier, Jr., Esq.,.....	Pair of Bucephala albeola, Baird. (*Buffel headed duck.*)
	Fishes for the Aquaria.
Mr. Gaven,.............	2 Eutainia sirtalis, Baird, and Girard. (*Garter Snake.*)
Mr. Miller, ...	Specimens of Copper Ore from the Bruce mine.
J. S. Thompson, Esq., ..	1 Cygnus Buccinator, Richards. (*Trumpeter Swan.*)
G. Barnston, Esq.,......	8 Percopsis —? nov sp. 3 Coltus —? 2 Rana —? 1 Salamandra —? } From Lake Superior.
E. C. David, Esq.,......	Specimen of wild rice from the prairies.
B. Gibb, Esq., ...	Horn of African Rhinoceros.
J. O'Brien, Esq., ...	Bubo Virginianus, Bonaparte. (*Great Horned Owl.*)
Mr. W. Hunter,.........	32 Specimens of the sternum (*Breast bone*) of Canadian birds.
	February 23rd.
R. Thompson, Esq.,.....	A silver, and copper coin of Napoleon III.
	2 busts of Daniel O'Connell.
	Model of the Great Eastern Steamship.
— Leslie, Esq., ...	Part of the stem of an Indian pipe found near Lake Ontario.
	Receptaculites occidentalis.
Mrs. Rollo, ...	English blackbird, (*Turdus merula, Linnæus,*) female.
— Boa, Esq., ...	Columnaria alveolata.
	Scops Asio, Bonaparte. *Mottled Ow* .
Mr. W. Hunter,.........	Troglodytes Parkmanni, Audubon. (female) *Parkman's Wren.*
	March 20th, 1863.
N. W. Bethune Esq.,....	A Canada bank note of the year 1792.
T. Devine, Esq., Quebec.	16 specimens of electrotype casts of fossils from Point Levis.
Mr. Charlton, Laprairie,.	Fish for the Aquaria.

LIST OF DONATIONS TO THE MUSEUM.

DONORS' NAMES.	DONATIONS.
	April 27th, 1863.
Geological Survey of Canada,	A large series of marine shells, echinodermata crustacea, sponges, &c., from the Gulf of the St. Lawrence, and a collection of the land and fresh water shells of Upper and Lower Canada, of which the following is a rough estimate: No. of Species. Marine shells 72 Land and Fresh water shells 81 Bryozoa, (*Sea Mats, &c.*) not yet determined. Echinodermata, (*Sea Urchins, Starfishes, &c*) 10 Crustaceans 4 Cirripedes (*barnacles, &c.*) 4 Annelida 6 Corallines, not yet determined. Sponges, (*nearly all new to science*) undetermined.
Dr. Dawson,	12 Species of marine shells and 3 of Echinodermata from Gaspé, Labrador, Nova Scotia, and the United States.
R. J. Fowler, Esq.,	15 Species of such Lower Canadian land and fresh water shells, as were wanting to complete the Society's local collection.
J. Ferrier, Jr., Esq.	A valuable and extensive series of foreign shells, corals, &c., of which the following is an estimate. Shells from Mazatlan, Mexico, about 80 species. Exclusive of these: Bivalves 87 species. Univalves 228 " Cirripedes. (*barnacles.*) Acasta Montagui, Leach, Britain. Corals. 5 species. Foraminifera. Nummulites nummularia? (Fossil from the Pyramids of Egypt.)
G. Barnston, Esq.	6 species of birds' eggs (*named*) from the Hudson's Bay Territory, and 1 from Lake Superior.
J. Ferrier, Jr., Esq.	15 species of birds' eggs from Canada and the United States.

THE NATURAL HISTORY SOCIETY OF MONTREAL IN ACCOUNT WITH JAMES FERRIER, JUN., TREASURER.

Dr.

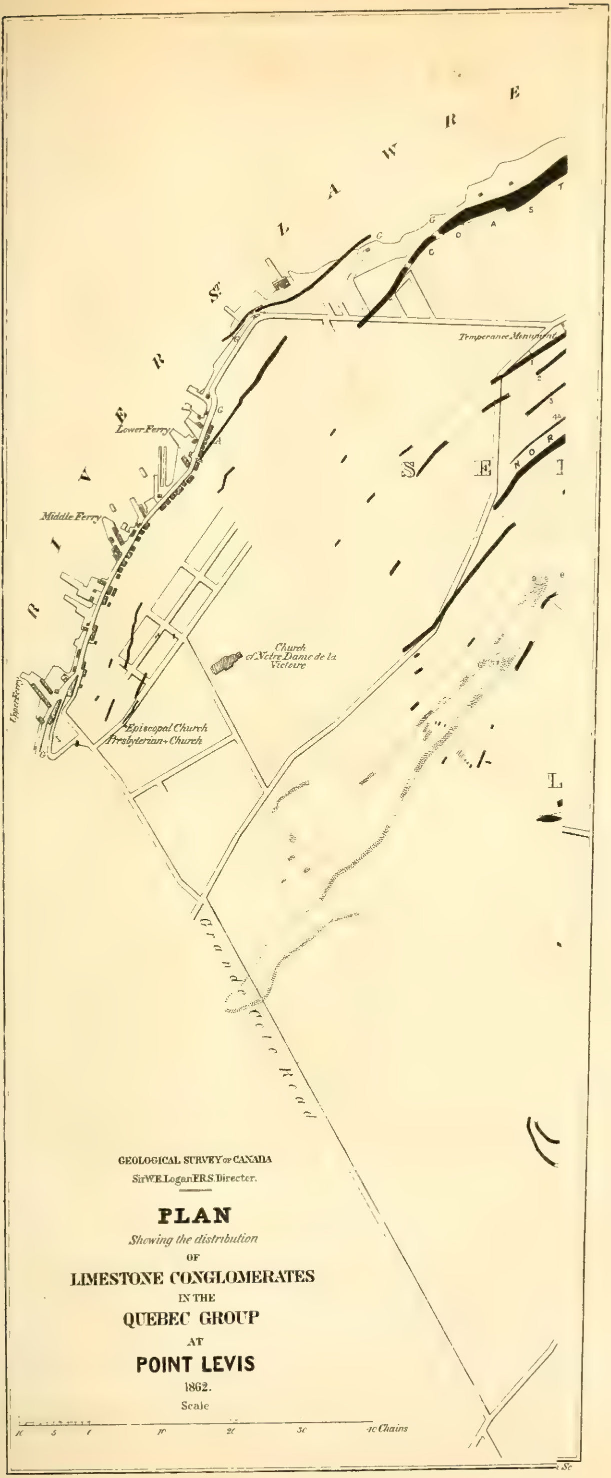
1863. May 1.	RECAPITULATION.		
To Cash paid,	Mr. Hunter's salary and note	$250	00
“ “	Mr. McCormick's acct. commission	30	00
“ “	Interest	251	48
“ “	City Assessment	40	00
“ “	Fuel	107	50
“ “	Water Rent	42	75
“ “	Gas Rent	29	08
“ “	Insurance	40	00
“ “	Books and Binding	179	96
“ “	Advertising and Printing	18	70
“ “	Repairs and Fixtures	119	90
“ “	McNab, arranging Herbarium	40	00
“ “	Legal Expenses	26	40
“ “	The Society's note	1000	00
“ “	Post Office account	5	73
“ “	Incidental Expenses	40	71
Balance in Treasurer's hands		353	10
		$2575	31

Montreal, 1st May, 1863.

Cr.

1863. May 1.	RECAPITULATION.		
By Cash received from	Government grant	$1000	00
“ “	Life Members	130	00
“ “	Admission fees to the Museum.	45	00
“ “	Proceeds of conversazione	27	05
“ “	Members' subscriptions	1357	00
By Balance in Treasurer's hands May, 1862		16	26
		$2575	31

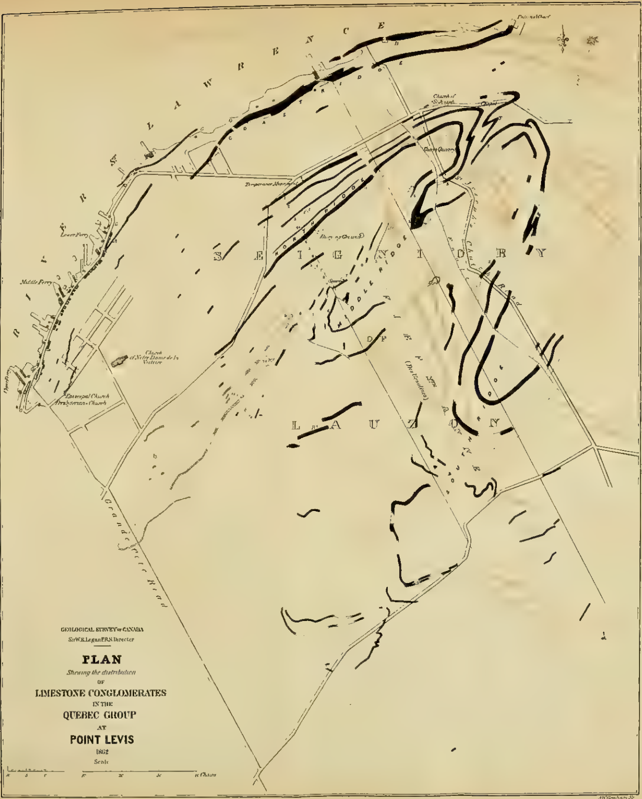
JAMES FERRIER, JUN.,
Treasurer, N. H. S.



GEOLOGICAL SURVEY of CANADA
Sir W. E. Logan F.R.S. Director.

PLAN

Showing the distribution
OF
LIMESTONE CONGLOMERATES
IN THE
QUEBEC GROUP
AT
POINT LEVIS
1862.

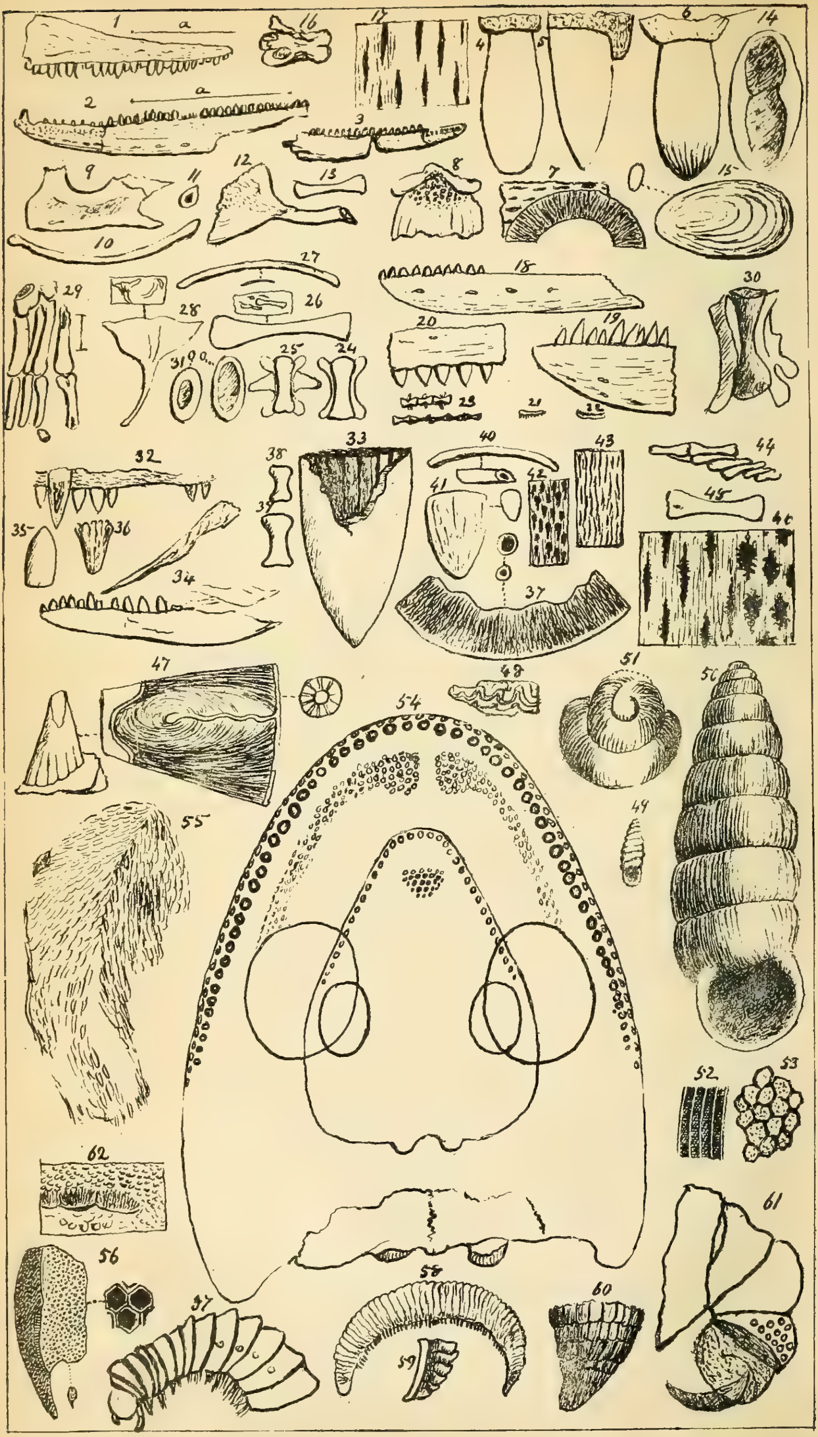


GEOLOGICAL SURVEY of CANADA
Sir W. E. Logan F.R.S. Director

PLAN
Showing the distribution
OF
LIMESTONE CONGLOMERATES
IN THE
QUEBEC GROUP
AT
POINT LEVIS
1862
Scale

A.W. Graham Sc.

PL. VI.



J.W.D. del^{t}

HYLONOMUS ACIEDENTATUS, D^{n}. H. WYMANI, D^{n}.

THE

CANADIAN

NATURALIST AND GEOLOGIST.

Vol. VIII. AUGUST, 1863. No. 4.

Art. XIX.—*Observations on the Geology of St. John County, New Brunswick.* By G. F. Matthew, Esq.

As some interest in the geology of this vicinity has been excited by the articles of Professor Dawson on the Upper Devonian Flora of eastern America, in the 'Canadian Naturalist' and 'Journal of the Geological Society,' a few remarks on the lithology, stratigraphy, and distribution of the older deposits of this neighbourhood may not be unacceptable.

In presenting them, however, I would claim a considerate criticism of the errors of one who is only an amateur of the science. I have confined my observations to a limited district, because it seemed to me that more permanent additions would thus be made to our knowledge of the geology of this part of the province than would be obtained by rambling over a larger field.

If I have given more prominence to details than may seem necessary, it is because I anticipate that the structure of the district which I propose to describe will explain that of the broken and hilly region east and northeast of St. John; and in a minor degree that to the westward.

The Devonian age of certain deposits in Gaspé, Nova Scotia, and Maine, had been recognized before the existence of strata of this age in New Brunswick was ascertained.

In various parts of the Bay of Fundy, red sandstones had been observed. Some were referred to the carboniferous period while others were found to be of still later origin. The deposits to which these remarks more particularly relate were all classed as Silurian.

In June, 1861, Dr. Dawson asserted the Devonian age of the sandstones of Perry in Eastern Maine, and, in consequence, those of St. Andrews, N. B., from certain fossil plants submitted to him for examination. Dr. Jackson had previously suggested this as the probable age of these rocks. The additional proofs accumulated by Prof. C. H. Hitchcock, have thrown much further light on their history, and their Devonian age is now clearly recognized.

Sandstones and conglomerates similar to these are known to occur at different points between Passamaquoddy Bay and the mouth of the river St. John, but their stratigraphy and position have not been determined.

On the eastern side of the harbour of St. John, and extending many miles along the coast, are extensive sedimentary deposits of great thickness, consisting almost entirely of fragmentary rocks, usually of coarse materials, varied by the addition of numerous beds of volcanic origin.

The lower members of this formation pass beneath the harbour and extend a few miles along the coast to the westward. It is in this direction that vegetable remains of the period when these rocks were formed, have been found in the greatest abundance and best state of preservation. The examination of these fossils has enabled Dr. Dawson to refer the strata in connection with them to the Chemung and Portage group of New York geologists.*

The sediments which underlie this formation are of equal or greater thickness; but few well-preserved fossils have been found in them, and these have not been studied; their age is therefore uncertain. The resemblance of some of these beds to the middle Devonian of New York has already been pointed out by the same observer.

To the eastward of St. John, Dr. Gesner (3rd Report, pp. 5-11) recognized two series of rocks, both of which he refers to the Silurian age, namely, an upper group of limestones, slates, and sandstones, containing remains of plants, mollusca, &c., and described as shelving from the southern side of a ridge of syenite; and an older group, in which he includes the conglomerates, clay slates, sandstones, talcose slates and trap beds of Mispeck and Black River.

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* The late Dr. Robb suggested this view of their age some years ago, although he had previously classed them as Lower Silurian (Johnston's Report on agricultural capabilities of N. B.). I am not aware that he published anything on the subject.

It will be one of my objects in the following remarks to show that the latter group is partly contemporaneous with, but for the most part less ancient than those to which Prof. Dawson's papers relate, and that Dr. Gesner's lower group is really to a great extent younger than his " upper series."

In the map and section accompanying these observations, I have endeavoured to show the distribution of the various groups of strata and the manner in which they have been tilted and folded.

Three principal folds in the strata are observable. The outer folds are anticlinal. Of these the northwestern skirts the south side of Kennebeckasis Bay, a lake-like expansion of the lower part of that river.

The southeastern runs parallel to the Bay of Fundy, and at a short distance from it. Its axis has a considerable inclination to the southwest, for the strata are found to bend over it (in ascending order) in that direction.

This peculiarity causes the deposit in the intermediate synclinal fold to expand to the westward and assume the appearance of a basin opening to the sea.

On examining the section it will be seen that of the two anticlinal folds there shown, the northern brings up beds of an age much greater than any which are seen in the southern, where the section crosses it.

Principal Dawson in his article on the Devonian Flora of Northeastern America,* published in the November number, 1862, of the Journal of the Geological Society, divides these pre-carboniferous beds into several groups, which with some modifications are given below. I have attached names to these groups (indicating the localities where the best and most typical exposures have been observed), which may serve the convenience of local observers, till the strata shall have been co-ordinated with deposits in regions better known.

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* I was favoured with an opportunity to peruse the rough draft of a part of this article, and have in consequence to a great extent avoided details relative to the rocks in the city and its immediate vicinity. Had I seen it in print before the following remarks were written, I would have omitted more, and thus have made them more concise and less repetitious.

PORTLAND SERIES (Nos. 7 and 8 of Dawson), thickness unknown. Granite and syenite, mica, schist and gneiss, limestones, clay slate, and sandstone. *Fossils*, fragments of plants in the upper beds.

COLDBROOK GROUP (No. 6 of Daw. in part), thickness 3,000 feet or more.

a. Greenish grey slate, stratification very obscure.

b. Bright red slaty conglomerate and dark red sandy shale.

c. Reddish conglomerate and grit, hard grey sandstone.

ST. JOHN GROUP (Nos. 5 and 6 in part of Daw.), thickness 3,000 feet or more; several zones of soft black and dark grey finely laminated shales alternating with zones of coarser grey slates containing numerous thin beds of fine grained sandstone. *Fossils*, lingula, a conchifer, annelides, coprolites.

BLOOMSBURY GROUP (No. 4 of Daw.), thickness 2500 feet.*

a. Basalt, amygdaloid, trap-ash, trap-ash slate; some beds of conglomerate. Thickness 2000 feet.

b. Fine grained red clay slate } Thickness 500 feet.
Reddish grey conglomerate }

LITTLE RIVER GROUP (Nos. 2 and 3 of Daw.), thickness 5200 feet.

a. "Dadoxylon sandstone," grey sandstone and grit with beds of dark grey shale, sometimes graphitic. Thickness 2800 ft.

Fossils. Numerous plants, several crustaceans, wings of insects. (C. F. Hartt.)

b. "Cordaite shales," grey, greenish, and red shales; reddish and grey sandstones, grits, and conglomerates, alternating with the shales. Thickness 2400 feet.

Fossils. Cordaites, Calamites, Stigmaria, Ferns, &c., for the most part identical with those of the preceding section.

(?) Granulite or granitic sandstone, micaceous slate, trap-ash.

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[*] Where groups appear on both sides of the synclinal fold the average thickness has been given. The measurements are to be regarded as merely approximate.

MISPECK GROUP (No. 1 of Daw.), thickness 1800 feet.

a. Coarse subangular conglomerate.

b. Fine-grained purple clay slate and grits surmounted by slate conglomerate.

(?) Red and green slate, basalt (stratified ?).

Topography.—The indentations in the coast line of the Bay of Fundy at Port Simonds and St. John harbour, cut directly across all the groups of rocks mentioned above, except those of the Portland series, which are crossed by the outlet of the St. John river.

In the peninsula thus formed between Kennebeckasis Bay and the Bay of Fundy, two hilly ridges, one skirting the former and the other the latter Bay, with an intermediate valley, are the most prominent topographical features.

The valley in its upper part forms the basins of several lakes (Loch Lomond, &c.), and forks as it approaches the sea. One branch through which the Mispeck flows, ends at Port Simonds; the other extends to the harbour of St. John, and is drained by Little River. An intermediate ridge of land, which extends a short distance into the Bay between the two ports, consists principally of the highest group of Devonian rocks, (see Section).

The uneven and hilly tract on the northwestern side of the peninsula is underlaid by the Portland series and Coldbrook group, and its surface is diversified by numerous lakelets and ponds.

The shales of the St. John group, being much softer than the deposit on either side, have suffered more from denuding agencies. They lie at the bottom of that branch of the central valley which ends at the harbour. Advantage has been taken of this depression to supply the city with water from lakes in the vicinity of Loch Lomond.

The volcanic and sedimentary beds of the succeeding group stand out boldly above the general level of the country wherever they attain a considerable thickness, and usually bear a generous forest growth.

In passing from the wooded slopes underlaid by rocks of this group to the arenaceous beds which succeed them, a notable change is apparent in the vegetation. Barren wastes and bare ledges of sandstone take the place of thick woods wherever the influence of the subjacent rock is not modified by the presence of a foreign soil.

These open moorland tracts are known as "Barrens," and are covered with a profusion of heath-like plants.*

In the upper part of the Little River group, some improvement in the character of the soil is manifest, more especially where volcanic sediments prevail.

But the agricultural capabilities of the land underlaid by these beds, as well as those of the highest Devonian group, depends very much upon the presence or absence of diluvial accumulations. The soils of the peninsula are indeed not remarkable for fertility, except where sea or river alluvium has been formed, or carboniferous deposits prevail. Large tracts are entirely barren and unproductive.

Portland Series.—The intricate structure and extensive metamorphism of these older beds renders their examination difficult and perplexing. They are introduced here principally on account of their connection with later deposits. Their general appearance has been so well described by Dr. Dawson, that it is only necessary to mention some peculiarities which did not come beneath his notice. Beside the syenitic gneiss observed by him, there are masses of syenite and granite in which no traces of stratification are discernible; also beds of mica schist and gneiss conglomerate. The upper part of the series is mostly calcareous, consisting of limestone strata separated by deposits of pyritous slates. Several of these are graphitic and contain small fragments of plants.

Coldbrook Group.—To these calcareous beds succeeds a group of rocks which does not hold a prominent place at St. John, but is largely developed to the eastward of that place. They are well exposed in the valley of Coldbrook, and further east where the following succession may be seen:

1. Hard greenish grey slate, stratification very obscure.
2. Conglomerate with bright red slaty paste.
3. Grey conglomerate.
4. Coarse reddish grit and conglomerate with purple sandstone.

Apparent thickness of the whole, 5000 feet.

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* Gaylussacia resinosa, Vaccinium Pennsylvanicum, V. Vitis-Idœa, Cassandra calyculata, Epigœa repens, Gaultheria procumbens, Kalmia angustifolia, Rhodora Canadensis, Corema Conradii, &c., are common on the ridges; while Sedum latifolium, Kalmia glauca, Andromeda polifolia, Myrica Gale, and a variety of other species occur in the hollows, which frequently expand into sphagnous bogs.

To the westward of St. John this group thins out rapidly. At the "falls" of the river it does not exceed 150 feet.

No organic remains have been detected in it.

St. John Group.—No division of these slates has been attempted, as there is a repetition of similar sediments; the strata are much plicated, and the only well preserved fossil—a lingula—which occurs in considerable number is common to the coarser beds throughout the group.

The great mass of the deposit consists of a grey clay slate often sandy, the layers of which present glistening surfaces owing to the abundance of minute spangles of mica. This rock frequently becomes very fine in lamination and texture, and dark in colour. Four thick bands of this kind occur, the uppermost of which has been denominated by Dr. Dawson papyraceous shale. They have as yet yielded no fossils.* The three bands of coarser shale which alternate with them include numerous layers of a fine compact grey sandstone, from a few inches to ten feet or more in thickness; a few are so highly calcarerous as to become almost limestones. The surfaces of the layers in the coarser bands are frequently covered with worm burrows, ripple marks, shrinkage cracks, scratches—apparently made by creatures gliding through the shallow waters in which they were deposited—and other evidences indicating that the slates are in great part of littoral origin.

Fragments and complete shells of a Lingula are scattered over the surfaces of the sandy layers, and thin seams composed entirely of these shells packed closely together are occasionally met with.

These shales maintain a comparatively uniform breadth between Loch Lomond and St. John, but to the westward of the city their thickness rapidly diminishes. No proof that they are unconformable to the deposits contiguous to their base and summit has been observed.

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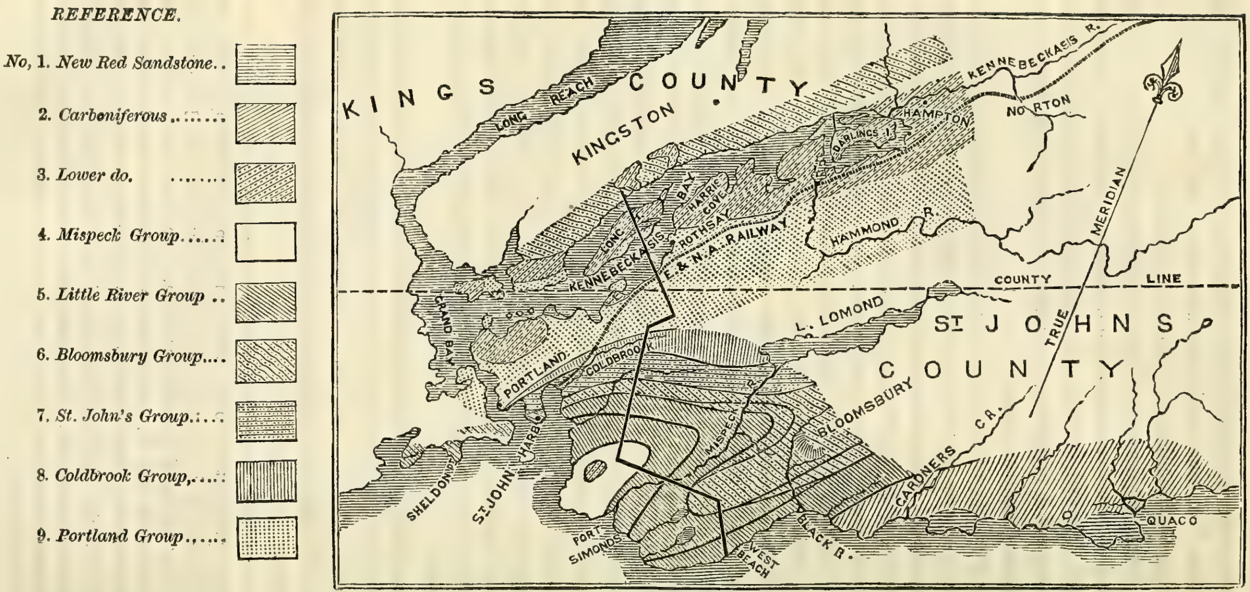
* Since writing the above, I visited, in company with my brother, Mr. C. R. Matthew, a locality on Coldbrook where he had previously met with loose pieces of fossiliferous slate. We found this rock in place near the base of the St. John group, and obtained from it, beside some obscure remains, a small orthoceratite, and numerous trilobites of two or three species, the latter so excessively distorted that not even the genera can be made out. These and the species discovered in the Dadoxylon sandstone by Mr. Payne, are, I believe, the only trilobites found *in situ* in the province.

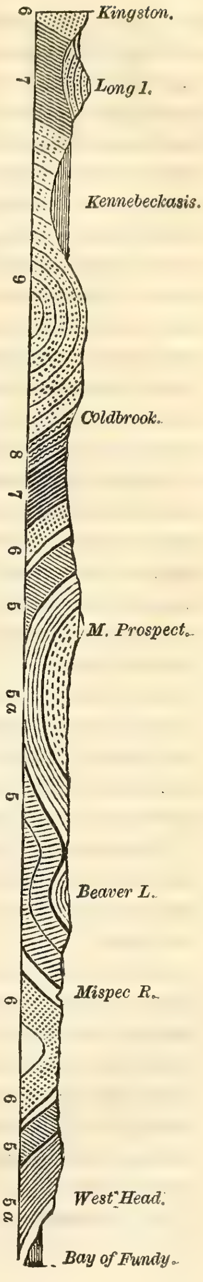


MAP OF THE VICINITY OF ST. JOHN, NEW BRUNSWICK.

Long Island in Kennebeckasis R. is principally composed of conglomerate and sandstone of lower carboniferous age, which rise in a bold and picturesque cliff from the water's edge at the eastern end. At the foot of this cliff and extending thence along the southeastern side of the island, strata of much greater age are exposed to view. They consist in ascending order of—1st. Granite and granitic gneiss; 2nd. Crystalline limestone and altered slate; 3. Thinly laminated grey shales with thin layers of fine sandstone much contorted. The whole dip to the northwest at an angle of 60° to 70°. In the shales, fragments of a lingula occur similar to that found in the St. John beds and probably identical with it. There are also numbers of worm burrows and other markings like those in the shales at St. John. The texture and position of this deposit as well as the obscure fossils which it holds, seem to show that it is identical with that which underlies the city. A small exposure of slates, evidently a continuation of those on Long Island, may be seen at Sand Point on the south side of the river, six miles southwest.

These limited exposures of slate seem to me to point out the occurrence of a belt of fine sediments on the northwest of the Portland series of rocks similar to that which is more clearly seen on the south-eastern side of St. John, &c.; and further to indicate that the valley of the Kennebeckasis, now mostly filled with carboniferous deposits, was originally scooped out of the soft beds of the St. John group.

Bloomsbury Group—*a. Volcanic beds.* At the centre of the parish of Simonds, St. John County, rises a high hill called Bloomsbury mountain, the western termination of



Section from North to South, on the line marked on the Map.

a ridge of land extending in a northeast direction through the middle of the county. The hill and ridge are on the southern anticlinal fold already alluded to. In the rear of Quaco the ridge is composed in part of syenitic and granitic rocks, but between the hill and the harbour of St. John no rocks of greater age than the trap beds of this group appear.

The elevation consists of basaltic trap, and is flanked on each side by beds of amygdaloid, trap-ash, and other products of volcanic origin, which also cover the crest of the anticlinal fold for two or three miles west of the hill. The succession of strata is best displayed on the south side of the hill where they succeed each other in the following order:—Basaltic trap, unstratified, of great thickness; bedded basalt, amygdaloidal porphyry, bedded basalt, hornblendic trap-ash, micaceous quartzite, vesicular trap-ash slate; thickness of the stratified deposits about 3000 feet. There is also on this slope a volcanic conglomerate, viz., fragments of trap rocks imbedded in trap-ash slate. The quartzite resembles some of the finer beds at West Beach and Black River, and the porphyry is that alluded to in Gesner's 3rd Report, p. 15. The trap-ash slate is in many places full of irregular vesicles, the sides of which are coated with minute crystals of quartz, calcite, and specular iron.

The great increase in bulk of the stratified traps, &c., at this place, and the nucleus of basalt over which they are spread, seem to indicate that it is one of those vents from which during the Devonian period, lava, ashes, and fragments of rock were poured forth and carried many miles to the westward.

The outcrop of the lava beds can be traced trending away to the north and west, till they cross the harbour at the southern end of the city, and disappear in the post-pliocene gravels west of St. John.

On the north side Kennebeckasis valley is bordered by a range of abrupt hills from 250 to 600 feet high, consisting of altered clay slate and sandstone, with numerous beds of greenstone interstratified, the whole series being much disturbed and usually vertical. They may be the equivalents of the volcanic sediments described above; but their outcrop is so straight for a distance of thirty miles, that they may prove to be part of an older series brought up by a fault.

b. Sedimentary beds.

On each side of Bloomsbury mountain, and separated from it by the forks of Black River, there are subordinate ridges of a dark red slate, capped by heavy beds of reddish conglomerate having a thickness of 2000 feet.

This thickness decreases so rapidly to the westward, that at Courtney Bay on the east side of the harbour it does not exceed 150 feet.

These sediments constitute a passage from the volcanic beds to the sandstones of the group above. No fossils have yet been obtained from them, and as they are thickest where the former are most prominent, they have been grouped as above.

LITTLE RIVER GROUP—*a. Dadoxylon Sandstone.*—This deposit in its lithological characters and fossils is the most constant and unchanging of the strata which have been shown to be unquestionably of Devonian age, and has been a valuable guide in tracing out the relations of the rocks eastward of St. John. A fine exposure of the whole of this sandstone and the greater part of the upper division of the group may be seen north of Mount Prospect (about four miles east of the city) where they rise from beneath the post pliocene gravel of Little River valley. The first consists of hard grey sandstone, with beds of grit and layers of dark grey shale at intervals, the whole having a thickness of 2000 feet. The fossils are *Calamites transitionis,* and fragments yielding discigerous and other porous tissues. The lower layers can be traced four miles east (to Latimore Lake), where they sink beneath gravel beds in the valley of the Mispeck River.

On the south side of the valley the sandstones again reappear with a westerly dip. Further down the river the strata incline to northwest and westnorthwest as they approach Port Simonds.

At the bridge over the Mispeck on Black River road the sandstone contains fragments of carbonized wood, *Calamites transitionis,* and *C.* sp.? A bed of dark shale at the same place holds *Cordaites Robbii, C. angustifolia,* and a calamite (*C. cannaeformis ?*), numerous stems of ferns and leaflets and broken fronds of two species (one is probably *Neuropteris polymorpha,* Daw.) A few beds of grey pebble conglomerate occur in the sandstones of this valley, and the thickness of the deposit is much greater than at Little River; and further west (being about 3600 feet) an outcrop of grey sandstones, which I have, no doubt belong to this series, was traced for several miles along the southeastern side of Bloomsbury axis. They rest conformably on the lower division of the Bloomsbury group, being separated from it by a thin band of dark red slates, probably representing the upper division. Beds of dark shale, which are intercalated with the sandstones, hold stems and other fragments of plants.

The upturned edges of these rocks, so remarkable for the abundance and perfection of the flora which they contain, have thus been traced around a double curve from Manawagonis to Black River, a distance of more than thirty miles and therefore spread over an area of sixteen miles in breadth.

On a grey slate, just above the most prolific plant-bed at Duck Cove, distinct rain marks like those obtained from the red sandstones of Connecticut were observed.

It will be observed that from the base of the Bloomsbury group to the top of this sandstone there is a series of deposits similar to those of the Coldbrook group, viz., volcanic sediments, red slates and conglomerates, grey sandstones.

b. Cordaite shales.—At the locality north of Mount Prospect, there is an excellent exposure of this as well as the lower division of the Little River group. By increase in the bulk and frequency of the finer beds, the sandstones gradually pass into arenaceous shales of greenish, grey and red colours, which frequently alternate with reddish and grey sandstone and grit,* the latter predominating east of this place, while the shales are more prevalent in the western extension of the deposit. Near its upper limit it approximates in the increase of coarser sediments to the lower beds of the Mispeck group; from these, however, the older conglomerates are easily distinguished by the small size, great number, and roundness of the quartz pebbles. *Cordaites Robbii* has been found to characterize these shales throughout nearly their whole thickness of 2300 feet. They cover an extensive area in the valley of Mispeck River, owing principally to a secondary fold in the strata (see section).

A thick series of micaceous slates and imperfectly formed granites and granulites or granitic sandstones with beds of trap-ash, conglomerate grit and limestone occur on the Bay shore at West Beach and Black River; and with their contained minerals are described in 3rd Report on Geology of New Brunswick. At the point where they are crossed by the section they present the following succession :

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* In two-thirds of the thickness of these shales there are thirty-seven distinct alternations of these coarser beds with the shales, varying from two to forty feet in thickness. In the upper third the sandstones become redder, and some thick beds of a coarser conglomerate appear.

1st. Red clay slate, and grit, and coarse reddish micaceous slate, resting upon the Dadoxylon sandstone.
2nd. A thick mass of granulite and imperfectly formed granite, with beds of trap-ash.
3rd. Grey micaceous slate.
4th. Reddish sandstone and grit, overlaid by coarse conglomerate holding beds of hematite.
5th. Dark grey micaceous slate, and basalt (stratified ?).

A short distance to the eastward, the quasi-granite passes into schist abounding with volcanic ash beds, and overlaid by similar strata containing several large beds of iron one.

Further east in the same metamorphic belt are a number of thick belts of impure limestone much altered, and hard clay slate with copper pyrites. The highest beds exposed at Black River are red and green clay slates, beds of trap-ash and basalt, resembling the volcanic sediments of the Bloomsbury group. The position of these metamorphic beds will be discussed further on.

Mispeck Group.—Filling the centre of the basin of Devonian rocks intervening between Little River and Mispeck River, and having a breadth of about two miles, is a group of sediments in which no organic remains have been found, and which there is reason to suppose should be separated from the fossiliferous strata below, although resembling the latter in appearance and equally metamorphosed. West and north of Mount Prospect where the cordaite shales disappear beneath the stratified gravel which covers the top of that hill, the dip of the beds at the base of this group rapidly diminishes from 30° to 15°, and the strike at the same horizon varies 10°. The lowest member is a coarse reddish conglomerate having a red slaty paste filled with large subangular fragments of a grey altered rock, like the lower slate of the Coldbrook group. It also contains fragments of reddish sandstone and a few pieces of impure slaty limestone. The conglomerate is overlaid by thick beds of purple clay slate, which by the accession of coarser materials becomes a slaty sandstone and grit filled with white particles. The highest member on the line of section is a slaty conglomerate holding fragments of slate and sandstone. The strata of this group are much thicker on the north than on the south side of the basin. An isolated deposit of red slate resembling the finer beds of this group, rests against a mass of altered rock which seems to be a continuation of the Bloomsbury volcanic beds, at Taylor's Island, west of the harbour of St. John.

Associated Deposits.—These consist of sediments mostly arenaceous, referable to the carboniferous and new red sandstone formations.

Lower carboniferous.—The upper part of the valley of the Kennebeckasis river is filled with deposits of carboniferous age; in the lower part of the valley these rocks have been to a great extent removed by denuding agencies, and only detached masses remain. They seem divisible into two principal sections, viz.:

A lower—consisting of coarse red conglomerates, red sandstones, and red shales. Fossils—Algæ and stems of land plants.

An upper—comprising grey sandstones and grey and brown shales.

The lower beds were at first referred by Dr. Gesner to the new red sandstone, but subsequently on account of their resemblance to sandstones, gypsums, &c., of Minas Basin, to the lower carboniferous formation.

The discovery of certain plants in the shales of the upper division at Norton station and Darling's Island in King's County, enables me to confirm the latter view of their age. At the latter place gray shales intercalated with grey sandstones hold the following species:

Lepidodendron elegans, *L. corrugatum*, and a species resembling *L. Sternbergii*, also abundance of spore-cases of Lepidodendra. *Cyclopteris Acadica*, Daw. (or a species closely allied,) a carpolite (?).

The beds near Norton Station, which were cursorily examined by Mr. C. R. Matthew last summer, are described as a thick undulating series of grey and black shales and shaly sandstones. Many of the layers are ripple marked and dotted with small bilobate impressions, and contain small fragments of land plants. Broken specimens of *Lepidodendron corrugatum*, Daw., and *Lepidodendron elegans* were obtained here.

At Apohaqui, in beds belonging to the same series, a cordaite (or stem of a large fern) was found in the beds of bituminous shale, and seams of Albertite in sandstone were also observed. Further up the valley are thick deposits of bituminous shale and limestone, but their relation to the beds of Norton, &c., is not known.

The resemblance of these shales and sandstones to those of Horton Bluff and Gaspereaux river in Nova Scotia, is remarkable, both as regards fossils, and the condition under which the strata were deposited; and there is every probability that they are of cotemporaneous origin.

The conglomerates of the lower division are unconformable to the Portland series and St. John group, and have usually the following composition:

Paste—dark red clay or sand derived from granite, rarely a grey calcareous mud.

Pebbles—imperfectly rounded fragments, one foot or less in diameter, of

1st Granite or syenite.
2nd Metamorphic limestone.
3rd Mica slate.
4th Soft brown sandstone.

These rocks, except the last named, are derived from beds of the Portland series.

The pebbles in those beds which recline on the flanks of the hills on the north side of Kennebeckasis Bay, are however mostly from the traps, altered slates, &c., on which the conglomerates there rest.

In rear of the post-pliocene plateau at Red Head, on the east side of St. John harbour, is a small isolated deposit of conglomerate terminating in a cliff seventy feet high. It probably rests on the tilted edges of the lower beds of the Mispeck group, and is much less coherent than any of the Devonian conglomerates of the vicinity. The layers incline to the northwest at an angle of 30°. The paste of the conglomerate is a dark brownish red sandstone, enclosing fragments of 1st granite, 2nd grey metamorphic limestone, also pieces of trap, mica slate, and soft brown sandstone. The deposit is therefore in every respect similar to the conglomerates of the lower Kennebeckasis.

Carboniferous.—There is a limited deposit of this age extending along the coast from Emerson's Creek near Black river to Quaco, which is unconformable to the micaceous slates, &c., of Black river, and which contains a flora more like the ordinary forms of the coal measures, than is that of the Kennebeckasis beds. The genera Megaphyton (?), Sigillaria, Calamites, Cordaites, Asterophyllites, Sphenopteris, Neuropteris, are represented.

New-Red-Sandstone.—Bright red sandstones with some pebble beds, skirt the sea shore for a few miles near Gardner's Creek, and may be seen both on the east and the west side to rest upon the upturned edges of the carboniferous beds just referred to. They dip to the northwest, and hold fragments of coniferous wood.

Metamorphism.—In comparing the appearance of the beds of the Portland series to that of the Laurentian formation in Canada, Dr. Dawson indicates the apparent antiquity of the former and the extreme metamorphism which the older strata have undergone. In the upper part of the series, however, the change is not so complete, and small fragments of plants may still be detected in the shaly layers. In the St. John slates metamorphism has not proceeded so far, and the two highest Devonian groups present still less alteration in their shales, though the coarser sediments are often strongly cemented, the vegetable remains of the sandstones converted into anthracite, and the lustre of graphite given to the ferns, &c., which the finer beds contain.

As soon as we pass to the Lower Carboniferous deposits a wide distinction is this respect is at once apparent. The vegetable remains which they contain have the appearance of plants from unaltered coal-measures. The conglomerates also differ largely from those of the Devonian series in their incoherence, and many of the shales are scarcely harder than the dried mud of a pond.

Beside the regional metamorphism which characterizes all the Devonian and subjacent deposits, some of the beds have undergone a local change, which is most prominent in the volcanic sediments. By an alteration of this kind the stratification of the lower beds of the Coldbrook group has been almost obliterated.

In the Bloomsbury group it is very marked, because the deposits above and beneath have undergone much less change. Several of the finer beds of this group have been converted into quartzites and micaceous slate.

I have already alluded to a group of metamorphic strata at Black river and vicinity, which have been considered to be much older than the fossiliferous deposits in the vicinity of St. John. That they form a part of the Upper Devonian series seems clear, because,—

1st They overlie the Dadoxylon sandstone conformably (or nearly so).

2nd They underlie carboniferous deposits unconformably.

3rd They partake of the flexures of the Devonian series, which preceeded the formation of the Lower Carboniferous conglomerate.

Their unusual metamorphism is evidently caused by the abundance of volcanic debris with which the beds are charged. I have connected them with the cordaite shales, but it is quite possible that the upper part may be altered beds of the Mispeck group.

Dynamical Features.—The thinly laminated strata of the St. John group are in many places drawn up into sharp folds, having oblique axes directed to the west and southwest, and inclined to the horizon at various angles. The markings on the layers show that they have been inverted in some places where these plicatures cannot be traced. The real thickness of the group may therefore be much less than we might, from a cursory examination, be inclined to suppose.

The grander folds of the Upper Devonian and older beds have already been described. That these were induced at the close of that epoch is evident, because the materials of which the fragmental rocks at the base of the Lower Carboniferous strata on the Kennebeckasis are composed, have been derived from beds brought to the surface by the abrasion of one of these folds, and because at one locality these rocks rest on the upturned edges of the higher Upper Devonian strata. Physically therefore, the line of separation between the two ages is strongly marked in southern New Brunswick.

This fact stands out with greater distinctness when we consider that 2000 feet or more in vertical thickness of what had already become solid rock, were removed from the tops of the folds in the older beds, before the materials of which the Kennebeckasis conglomerate is formed, were exposed. And we cannot well avoid the conclusion that currents or other agencies of vast force or long continuance (perhaps both), held sway over this region at the opening of the carboniferous age. The wide hiatus between the two series also excites the suspicion that the conglomerate alluded to is not at the base of the carboniferous series. The gap which intervenes may be narrowed by the bituminous shales, &c.,

of Albert, which according to Dawson are beneath the carboniferous conglomerates of that county.

The Carboniferous strata both in the valley of the Kennebeckasis and on the coast have been crumpled up in the same manner as the Devonian of the intervening district, but at a later epoch. In the small deposit of New-Red-Sandstone at Gardner's Creek, these plications do not occur.

General Remarks.—In reviewing the general features of the deposits which I have attempted to describe, the rarity of deep water accumulations is worthy of note. Above the limestones of the Portland series the strata consist almost entirely of littoral or subærial deposits; the finer shales of the St. John group and some limestones at Black river being the only beds which indicate a deep water origin. Ripple-marks, and other evidences of a sea-margin have been observed at three different levels in the St. John slates, and also at several places in beds of the Little River group and as already stated rain marks also occur.

The evidences of volcanic activity during the period marked by the Coldbrook beds, and the great accumulations of lava, ashes, and volcanic mud, which form the bulk of the Bloomsbury group, as well as the proof of renewed igneous action met with among the vast beds of gravel, sand, and clay subsequently formed, show that in some points the circumstances which attended the formation of Devonian deposits in eastern America differed widely from those which prevailed at the west.

The source of the detritus out of which the Devonian beds at St. John have been formed has not yet been ascertained; but that it is to be sought for in an easterly direction is obvious, since all the deposits (except perhaps the highest) increase in bulk and coarseness of material when traced in that direction. Its origin is probably closely connected with that of the volcanic beds, which as I have already shown are largely developed to the eastward.

An intimate relation between volcanic deposits and red sediments seems to exist in these beds, the latter appearing to be a consequence of the former. Thus red shales sandstones and conglomerates succeed the lowest member of the Coldbrook group; and a similar succession on a larger scale occurs in the Bloomsbury beds. If I am correct in referring the metamorphic strata of Black river to the cordaite shales or Mispeck group, a similar succession appears in the higher beds, not vertically, however, but horizontally.

A section of the Devonian rocks at Perry, Maine, is given by Prof. C. H. Hitchcock, in the Report of the Maine Scientific Survey, 1861, p. 252, which indicate three geological epochs. 1st Silurian ; 2nd When beds of trap were spread over the upturned edges of the Silurian strata ; 3rd The period when Devonian sandstones were deposited unconformably on the trap. This trap seems to hold the position of the Bloomsbury beds at St. John. But no evidences of unconformability between the latter deposits and the overlying plant beds have been observed. Prof. Hitchcock therefore surmises that the Perry sandstones may be equivalent to the higher beds at St. John (Cordaite shales and Mispeck group).

In confirmation of this view, I may remark that the Dadoxylon sandstone thins out both to the southwest and southeast, and notwithstanding its great thickness may be a comparatively local deposit. Moreover between the highest and the lowest beds of this sandstone, there is a decrease of fifteen to twenty degrees in the dip, showing that a subsidence of the area over which the deposit is spread took place while it was in process of formation. If this oscillation extended to the western part of the Bay of Fundy and no beds corresponding to this sandstone were formed there, a disordance between the dip of the trap and sandstones, such as is exhibited in the section at Perry, would result.

I have already alluded to a rapid and equally great decrease in the dip of the beds at the base of the Mispeck group. Uncon formability to the extent of thirty degrees may therefore occur where the highest and lowest of the Upper Devonian beds are in contact. This seems to be the case at Taylor's Island.

Note by Principal Dawson on some fossils referred to in the above paper.

Mr. Matthew has forwarded specimens of the Lower Carboniferous and New-Red-Sandstone plants referred to in the above paper. Among the former, I recognise most of the characteristic plants of the Lower Coal Formation of Horton in Nova Scotia, and have no doubt that the beds containing these fossils in New Brunswick, are strictly equivalent. The fossil wood from the New-Red-Sandstone, though not well preserved, appears to be coniferous, and to have one row of discs on the cell walls, in the manner of the mesozoic pines of the genus *Peuce* or *Pinite*.

The discovery of these plants by Mr. Matthew is of great importance in connection with the Devonian flora of the underlying beds ; and it is extremely interesting thus to find, in so limited an area, a rich Devonian flora, two of the members of that of the Carboniferous system and indications of a mesozoic flora, in beds whose order of superposition is so distinct. It further affords an excellent illustration of the geological importance of the study of fossil plants, which first threw light on the age of these beds, and without which, in the absence of well-marked animal fossils, their position in the series of deposits would still have been uncertain.

Art. XX.—*On Ailanthine.* The silk yielded by the Saturnia or *Bombyx Cynthia*, with Remarks on the *Ailanthus glandulosa* or False Varnish Tree of China. By Robt. Paterson, M.D., F.R.C.P.E., Corresponding Member of the Botanical Society of Canada, &c., &c.

(*Read before the Botanical Society of Canada, January* 26, 1863.)

There are few individuals who have not watched the interesting changes which take place in the larvæ of the *Bombyx Mori*, or common silk-worm, from the point of its exit from the egg until it has reached its full butterfly existence; and many there are who have been sadly disappointed at the mortality which comes over a brood of silk-worms in a single night from some cause or causes unknown and consequently equally unremediable. Such epidemics are continually occurring in China as well as Europe, and constitute one of the greatest obstacles to the introduction of the culture of the silk-worm into this country. What occasions this sudden decimation of these insects has never been determined, but has long led to a wish, on the part of those interested, that a more hardy breed of silk-producing worms could be introduced into Europe, even although the produce was coarser, and of a worse colour, than the ordinary mulberry silk.

Recent information, through our missionaries in China, leads to the knowledge that there is a considerable number of worms used by the Chinese, in different districts, for the production of silk of various qualities and coarseness. These varieties of silk are used in China principally for the manufacture of dresses for the peasantry. Of late, however, some of these have reached this country, and have been considered durable and excellent. Could we but rear such silk in our country, as we hope shortly to be able to show that we can do, how much of the present overwhelming distress, which is visiting our manufacturing districts in consequence of the American war, might be avoided. Such material, if not used alone, might be readily mixed with cotton or wool; and thus many new and beautiful, if not very durable, fabrics might be produced.

In 1814 Dr. Roxburgh* published an interesting memoir on the silk-producing moths of the East Indies, and soon afterwards the Arrindy, or Palma Christi silk-worm was introduced into Europe. The Castor Oil Plant, in this climate and in the north of France is but a delicate shrub; in the south of Europe, however, where the temperature never reaches the freezing point, it becomes a tree of very striking aspect, with large and richly tinted foliage. In such districts, therefore, the Arrindy moth thrives well, having plenty of food, undergoing its changes rapidly, and yielding five and six crops annually of silk of excellent quality. What was required for our climate, however, was an insect which, while sufficiently hardy to stand our cold springs and autumns, would also be regardless of storms, rain, dew, &c. Such a worm was first sent to Europe by the Abbé Fantoni, a Piedmontise missionary in the province of Shan Tung. He sent some cocoons immediately after the first gathering in 1856, to some friends in Turin. The name of the tree, on the leaves of which they lived was to him a mystery, but he described it as being like the leaf of an acacia: so when the young brood hatched, various and many were the plants tried for their food, until the leaves of the *Ailanthus glandulosa* were presented to them; these they immediately ate greedily, and always preferred them afterwards to any other kind of food.

There can now be little doubt but that the Arrindy or Palma Christi moth, introduced into Europe from Dinagepore and Rungpore in Bengal in 1854, and the Ailanthus moth introduced into Europe from the province of Shan Tung in China, in 1858, are one and the same animal. The insects introduced in 1854 were delicate, and did not stand much lowering of the temperature, besides the tree on which they fed perishes at 32° or 33° Fah. The insects introduced in 1858 were hardy, stood rain and cold, and the tree which they preferred is a hardy one in our climate. Those introduced in 1858, from China, would not eat the Palma Christi, and very naturally it was believed that they were different insects; upon examination, however, they turn out to be the same. Their changes, the colour of their larva, the character of the cocoon, the kind of silk, and the characterizing marks of the moth itself pronounce them at once to be the same animal. But how have these animals acquired such different habits and tastes? This can only be explained upon the supposition that a long period of hardening in a temperate climate like the province of Shan Tung would produce in course of time a more hardy progeny, feeding habitually on a common plant of the country; while the more natural and more effeminate brood of Central India, preferred as food the leaves of a plant which will only flourish in warm latitudes. Unless specific distinctions exist it is clearly a bad plan to distinguish an insect from the peculiar plant it eats, for this may be a simple point of preference,—if it cannot get the one it will eat the other and thrive on it; besides a long period of hardening will often enable an animal to live and thrive on a vegetable very different from its native food. We need only example the ordinary *Bombyx Mori* or common silk worm, the finest varieties of which, after passing a year or two in our climate, will live, and thrive, and spin beautiful silk on the common lettuce. Of the tree on which the ailanthus worm feeds it may be necessary here to speak shortly; we shall have to describe the animal itself more fully afterwards.

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* Linnæan Transactions, Vol. 7.

It appears that the tree was originally introduced into this country by the abbé d'Incarville, in 1751, as the "Vernis de Japon" tree, or that which yielded the famous Japan or China varnish. This turned out, however, to be a mistake, as the true Japan varnish tree has since been introduced into Europe. Since this latter introduction the *Ailanthus glandulosa* has been known as the false varnish tree. It is a hardy plant in our climate, standing severe winters well, and producing an abundant crop of leaves especially from young shoots in early summer. It has no especial partiality for particular varieties of soil, thriving as well and producing as abundant a crop of leaves in the most barren soil as in the richest loam. It seems equally indifferent, too, as to the characteristics of the atmosphere in which it lives, healthy young trees being observable in the squares and smoky environs of London. The advantages of a plant such as this in the rearing of a hardy animal on its foliage need not be pointed out. Throughout France generally this tree flowers and seeds freely, and the seed sprouts and grows readily in Great Britain; but in addition to this method of propagation, another exists in the roots, which if cut into pieces like the potato spring forth and grow luxuriantly; no plant indeed can be more easily grown, or more easily increased when grown, than the *Ailanthus glandulosa.* But to enable this plant when grown to yield a proper supply of food for the ailanthus worm, it is necessary to cut it down and grow it ozier-like. In this way young shoots spring forth abundantly, and bear large and delicate leaves fitted for the young worm,and greedily devoured by the older ones. They have an additional advantage also that when the insects are placed upon them in the open air they are more easily protected by nets, &c., from the depredations of birds, insects, &c.

So much for the plant on which the animal feeds. Let us now turn to the insect inself :—I have already stated that the ailanthus silk worm was introduced into Europe in 1856.. Its cultivators have not been idle since that time as we find that M. Guerin Meneville endeavoured to introduce this worm into France. His first experiment did not succeed but the following year he reared a satisfactory crop of cocoons in the open air ; this, however, and all the efforts of the Societé d'Acclimatization of Paris were not sufficient to effect the general introduction of the animal into France. It became necessary for him to show that agriculturalists might derive a profit, and a good one, from the rearing of this insect.

Energetic, and thoroughly convinced ofthe success of such an experiment on a large scale, he induced personal friends to experiment on a larger scale at Toulon, in Provence, and at Chinon (Indre et Loire), the one being nearly in the south, the other in the centre of France.

At Chinon, for instance, 4,500 worms were placed upon flourishishing thickets of ailanthus, which had been cut down and grown as bushes with that intention. Their development progressed satisfactorily, and they yielded 3515 excellent cocoons, after suffering without injury, rains, heavy storms, and the attacks of birds and insects. The result of the experiment was a loss of about a fourth part, while the average loss of mulberry silk-worms is about one-half.

M. Meneville, after some careful experiments and calculations which were submitted to the imperial government, has thus stated his profit and loss account, on the rearing of ailanthine, or the silk of this worm, produced in districts south of Paris.

	Francs.
Twelve acres of ailanthus copse, share of expense of planting and annual expense of keeping up..................	2030
Average of receipts from two crops of ailanthine.........	9945

Which leaves a balance of 7915 frances for the twelve acres, or in round English numbers, £330 for twelve acres, or £27 10s. per acre. In India and China there are said to be six crops of silk annually; in the south of France two or three crops, but in the north of France and Great Britain two at most, and more securely one crop might be relied on. Let us take one good crop and see how our profit and loss account would stand in Great Britain The half of £27 10s. or £13 15s. would be the result, or about it; and be it remembered, for land, that after the planting of the ailanthus it requires no manure or tillage whatever, and the kind of soil being that on which nothing else would grow, provided always that it has as sheltered and sunny an exposure as possible. It always occurred to me that the climate of Canada would be especially favourable for the growth of ailanthine. The insect and the plant on which it feeds will stand any amount of cold; and when the Canadian summer would arrive, rapid growth would take place in the tree, followed by hatching of the worm; in this way food would be speedily produced for the young brood, and two if not three crops of silk taken from the trees during the season. The experiment is one worthy of trial.

In England and Scotland, for the last two years, some experimenters have been at work but as yet without any quantitative result. In the spring of 1862 I received, through the kindness of a friend, fifty eggs of the *Bombyx Cyrthia;* they hatched in about ten days after their arrival; they were fed with cut branches of ailanthus; kept in the ordinary temperature of the atmosphere, but under glass. Of the fifty worms (for the eggs all hatched) with all my inexperience, I had thirty-five large and fine cocoons being a result not far short of that in the central districts of France. With more experience and with growing plants prepared for the trial, I do not fear for the result of a quantitative trial in Scotland at any future year.

It is my intention, in describing this insect, to follow the different changes which it undergoes from the egg onwards until we arrive at the characterizing moth itself, from which distinctive marks and pecularities are chiefly taken.

The Eggs. These are about the size of a large pin head, twice as large as those of the mulberry silk-worm with which we are all familiar. They are yellow coloured, equally large at both ends, flattened from above downwards, and with a depression in their centre. They soon change their colour to a greenish black, the colour becoming more marked the nearer the point of hatching is at hand. The caterpillars are hatched from ten to fifteen days after the eggs are laid according to temperature.

The Caterpillar. When the worm first escapes from the egg it is exceedingly minute; the colour of the segments of its body at this early stage is obviously yellow, but there are so great a number of black spots and dark coloured tubercles over it, as to give the impression that it is of a black colour; during the *second period*, that is to say after the first change of skin, the yellow colour becomes more marked, but the spots and tubercles are still black. During the *third period*, they become nearly pure white, arising from the presence of a white mealy secretion over their bodies, destined, obviously, to protect them from rain or dew, as water will not fix on it; the spots and points of the tubercles are still black or bluish black.

During the *fourth period* the body is at first white, but gradually changes to a pale green, the tubercles assuming the same colour, and soon the head, the feet, and the last segment become of a golden yellow; the flowery secretion still, to a certain extent, exists, and there are always black points upon the segments or rings of the body.

During the *fifth period* the emerald green colouring becomes more intense, the points, as to segments, assume a soft black colour, and the extremities of the tubercles a marine blue. The caterpillar grows rapidly during this stage, eats largely and greedily till it attains the length of from $2\frac{3}{4}$ to 3 inches long, it then ceases to eat, becomes torpid for a few days, and then, after fastening a few leaves together at the extremity of a leaf or branch it begins its cocoon. Such is the general character of the changes which this caterpillar undergoes; but to enable those who may follow out this inquiry to know when these changes may be expected and the size of the animals in them I will give a short table of my own experience, and that of my friend Dr. Gudwad, both in Scotland :—

Eggs hatched, 28 to 30th June..............size $\frac{2}{8}$ of an inch.
First change, 7 to 9th July ....size $\frac{1}{2}$ of an inch.
Second change, 13 to 15th July ....size 1 inch.
Third change, 20 to 22nd July ....size $1\frac{1}{4}$ inch.
Fourth change, 28 to 30th July ....size $1\frac{1}{2}$ to 2 inches.

From this time till the period when it begins to spin it rapidly grows till it reaches from two and a half to three inches long, depending upon the abundance and quality of its food.

The experience of my friend Dr. Gudward is as follows :

Eggs hatched 19th Sept.
28th " 1st change began.
5th Octr. 2nd change began.
12th Octr. 3rd change began.
21st Octr. 4th change began.
3rd Nov. began cocoon.

The temperature ranged from 47° to 55°.

The Cocoon. I have already remarked that after a short period of torpidity when no more food is taken and during which the remains of the undigested food is passed by the worm in abundance, it begins its cocoon by fastening some threads of silk to the end of the branch or leaf stalk, and, after binding some leaflets together, it spins its cocoon in the hollow thus formed. The colour of the silk is of a yellowish brown colour, very like, indeed, to that of a decayed leaf. In weaving its cocoon this worm leaves at its lower extremity, an elastic opening for the exit of the moth. The threads at this opening are not cut across, but simply turned and laid one over another. The silk of this worm has not as yet been unwound in a continuous thread ; this, doubtless, arises from the substance which glues the threads together requiring some other solvent than the warm water which so readily affects the solution of the gummy secretion of the mulberry silk. This however cannot long remain undiscovered in this country, as a chemical solvent for this secretion will doubtless ere long be found.* In China even there is reason to believe that this has been accomplished, as the last examples of ailanthine from that country are stated to leave no doubt of their having been unwound from the cocoon. Even the carded silk of this worm is abundantly used. In China it forms the most durable dresses of the peasantry,—dresses which are often handed down from father to son. In France this "flosille" or floss silk is abundantly used for weaving with thread and wool, and in the manufacture of fancy stuffs. At Roubaix, Nismes, and Lyons, it is imported from abroad in large quantities to the extent of 1,290,000 kilogrammes annually.

Mons. Geoffrey St. Hilaire, President of the Societé d'Acclimatization of Paris says :—"Here is the report of the weavers at

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*It has been stated by some that the cause of the silk not winding off, results from the slanting opening at the bottom of the cocoon, admitting water, and thus sinking it and breaking the thread. This explanation is not satisfactory and is inconsistent with fact.

Alsace, who have made use of ailanthus silk. M. Schlumberger has found the cocoon very easy to card and spin; the thread obtained is less brilliant, strong and rough; it left no residue, not more than in combing the thread. It is a most excellent stuff for use in all manufactures where burre is employed. The cocoons are easily cleaned and they will take a good dye. This culture, made on a great scale, will furnish in abundance a finer and stronger floss than the mulberry silk-worm. The worm remains in the cocoon in the chrysalis condition for from twenty-six to thirty days, at which time the moth makes its appearance coming quickly and easily through the valvular opening at the extremity of the cocoon. At this time its wings are moist, soft, and folded up; and naturally upon emerging from the cocoon it seizes hold of the lower part of it, thus allowing its large wings to drop, become unfolded and stiffen. If this precaution is not taken when the moths are allowed to exit artificially, their wings never expand but remain crumpled up, the moth never regaining much activity with its wings in this state, and seldom connecting itself with the opposite sex. In rearing these moths therefore, it is of consequence to observe that upon their exit from the cocoon they have some substance on which they can climb up and allow their wings to hang down and become expanded.

The moths have been long familiar to us, in collections of Chinese Butterflies, brought to this country. It is large, the expansion of its wings being about five inches; the head and antennæ are greyish brown, the latter strongly pectinated; thorax and abdomen lighter grey, wings with a broad transverse light-coloured band near the middle, the space within which (forming nearly an equilateral triangle) is brownish grey, and that without ash colour, running into brownish grey at the margins of the wings, just within the margins there are two narrow brown streaks running parallel with them, somewhat interrupted before reaching a black spot near the apex of the superior wings; this spot is surmounted by a white crescent, and a zigzag white line runs from it to the tip. The basal portion of the superior wings is traversed by an ash-coloured bar commencing on the posterior edges next the shoulder, and after continuing in nearly a straight line for about half an inch is suddenly deflected and terminates on the anterior margin, between this bar and the transverse scapular line there is a pale longitudinal spot surrounded with black. The under wings likewise bear a similar spot but more crescent-shaped, and towards their base there is an ash-coloured arched bar bounded on the outer side with black. The under side differs principally in being paler and destitute of the angular and arched bars at the base of the upper and lower wings.* These moths, when in health and especially in sunshine, connect themselves and lay eggs in a few days. If they do not develope their wings or the temperature is low and without sunshine the males do not seek after the, females hence the eggs laid are often, under these circumstances, unproductive.

ART. XXI.—*The Air-Breathers of the Coal Period in Nova Scotia;* by J. W. DAWSON, LL.D., F.R.S., &c.

(*Continued from page* 175.)

VIII.—HYLONOMUS ACIEDENTATUS.

Plate VI, Figs. 1 to 16.

This species is founded on a single imperfect specimen obtained by me at the Joggins in 1859, and described in the Journal of the Geological Society, Vol. XVI. In this description, I mentioned, as probably belonging to this species, certain detached bones which I have since found reason to attribute to *Dendrerpeton Oweni.* These did not however materially interfere with the characters of species, which I shall give here from the fragments represented in Plate VI, Figs. 1 to 16, and which occur together in the matrix in such a manner as to render it certain that they belonged to the same individual.

In size, *H. aciedentatus* was about twice as large as the species last described. Its teeth are very different in form. Those on the maxillary and lower jaw are stout and short, placed in a close and even series on the inner side of a ridge or plate of bone. Viewed from the side they are of a spatulate form, and present a somewhat broad edge at top as in Fig. 4. Viewed in the opposite direction, they are seen to be very thick in a direction transverse to that of the jaw, and are wedge-shaped as in Fig. 5. There are about forty on each side of the mandible, and about thirty on each maxillary, as seen in Figs. 1, 2, and 3, of which the two first are magnified slightly, the last natural size.*

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* Sir H. Jardine's description of *Sturnia Cynthia,* and corresponding in every particular to ailanthus silk moth.

Since the publication of my previous paper, I have ascertained that the intermaxillary bones bore teeth of the form represented in Fig. 6. They are larger than the others, thick and coming to a blunt point, which is *seamed with longitudinal and slightly spiral ridges.* This singular tooth must have been a most efficient instrument for crushing and penetrating the coats of crustaceans and insects, or the bony armour of the smaller ganoid fishes. Remains exist at the extremity of the lower jaw, which show that a few teeth there also were larger than the others, but whether they differed in form cannot be determined. The pulp cavity of the teeth is less extensive in proportion than in *H. Lyelli*, and the structure in the cross section is simple, showing merely radiating ivory tubes, as in Fig. 7. The bone represented in Fig. 8, was found with these remains, and as it is too large for the last species, and different from anything known in *Dendrerpeton*, it probably belongs to the creature now under consideration. It is thin and smooth, except at the upper margin, where it has in the centre a group of small conical teeth. It evidently belongs to the palate, and somewhat resembles the palatal bone of *Menobranchus*, but is broader, and the latter has no teeth. Detached fragments of the skull show that its bones were thin and dense, and smooth on the surface as in *H. Lyelli.* That represented in Fig. 9 would seem to be a frontal bone seen from the inside.

The remains of *H. aciedentatus* are too scanty to warrant much certain inference as to its form. Its vertebræ would seem to have resembled those of *H. Lyelli*, but to have been elongated and more thoroughly ossified (Fig. 16). Its ribs are similar in form and proportion to those of the last named species (Figs. 10 and 11). A pelvic bone and some detached phalangial bones (Figs. 12 and 13) as well as very fragmentary limb bones, would indicate that its limbs were well developed. Its external scales are similar to those of the last species but larger, and a few fragments of skin show scales and appendages similar to those of *H. Lyelli*, but of greater dimensions (Figs. 15 and 62). The microscopic structure of its bone is also similar to that in the last species (Fig. 17). No doubt a more perfect specimen would show many points of difference between these species, not now appreciable;

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* In Prof. Owen's paper, J.G.S., Vol. 18, this bone is figured, but incorrectly stated to be twice natural size, and referred to *H. Lyelli.*

but in the mean time the very different form of the teeth is a sufficient distinction. In *H. Lyelli* these are conical and pointed. In the present species they are of a peculiar wedge shape—their diameter transversely to the jaw being the greatest at the base, while at the top they are sharpened to an edge. The peculiar form of the intermaxillary teeth may also serve as a distinctive character, though those of *H. Lyelli* are not yet known. The form of the vertebræ would further seem to indicate different proportions of body. On the whole, while this species is in all probability generically related to the last, it is certainly specifically distinct. Its habits and food may have been similar, but its dental apparatus was stronger and more formidable.

EXPLANATION OF PLATE VI, FIGS. 1 TO 16, AND FIG. 62.

Hylonomus aciedentatus.

Fig. 1—Maxillary bone, magnified, (*a*) natural size.
" 2—Mandible magnified, (*a*) natural size.
" 3—Portion of mandible, natural size.
" 4 and 5—Tooth, seen from the side and front.
" 6—Tooth of intermaxillary.
" 7—Cross section of tooth, magnified.
" 8—Palatal bone with teeth.
" 9—Frontal bone.
" 10 and 11—Rib natural size and cross section enlarged.
" 12—Pelvic bone.
" 13—Phalangial bone.
" 14 and 15—Bony scales magnified.
" 16—Broken vertebra.
" 62—Portion of skin with horny scales.

IX.—HYLONOMUS WYMANI.

Plate VI, Figs. 18 to 31.

This is the species of *Hylonomus* originally detected by Prof. Wyman in the specimens brought from the Joggins by Sir C. Lyell and myself. Remains of several additional individuals have since been found, but no skeleton approaching to completeness. I shall describe this the most diminutive of the reptiles of the Nova Scotia coal, with the aid of the fragments represented in Plate VI, Figs. 18 to 31, most of which are almost miscroscopic in size.

The skull seems to have been much of the same form as in *Hylonomus Lyelli*, but very thin and delicate, so that all the specimens hitherto found are crushed and fragmentary. The maxillary and mandibular bones are furnished with teeth which are bluntly conical in form, and in the latter bone seem to be confined to its front part, or to be very small posteriorly. They are thus much fewer in number than in the species last named. I have been able to make out only 22 in the lower jaw, and they are alternately large and small, as if replaced in this manner as worn out. Their structure is of the same simple character as in the other species of *Hylonomus*, and they have large pulp cavities.

The vertebræ of this species are singular and characteristic. The bodies are elongated and hour-glass shaped, with an internal cavity of the same form filled with calc spar (Fig. 30), and probably once occupied by cartilage. They have, in the dorsal region at least, strong articulating and lateral processes, and were furnished with numerous delicate ribs (Figs. 24, 25, 27). In one of my specimens as many as 38 of these little vertebræ may be seen lying together, and many of them attached to each other. This would indicate that the body was long and slender. It was furnished with limbs, similar to those of *H. Lyelli*, but very small and slender. The pelvis is of the same expanded form with that of the last species, and a pair of fore feet lying together on one slab, show the remains of four slender toes (Fig. 29). The bones of the limbs are very delicate and thin walled (Fig. 26). The bony scales are oval, and similar to those of the other species of the genus, but very small (Fig. 31.) I suppose it probable that the fragments of skin with imbricated scales represented in Plate V, Figs. 22, 23, and 24, may have belonged to this species, but I cannot certainly affirm that this was the case.

In length, *Hylonomus Wymani* could not have exceeded four or five inches, and its form was thin and slender. It may be questioned whether this little creature was not the young of one of the other species. The form of the vertebræ and teeth would, I think, prevent us from supposing that it stood in this relation to *H. Lyelli*. To *H. aciedentatus* it bears a stronger resemblance in these respects, though not sufficient to render specific identity probable; and the occurrence of so many specimens of the smaller species, without any of intermediate size, renders it likely that it did not attain to any greater dimensions.

Hylonomus Wymani probably fed on insects and larvæ, and searched for these among the vegetable debris of the coal swamps, which would afford to a little creature like this abundant shelter. It occasionally fell a prey to its larger reptilian contemporaries; for quantities of its tiny bones occur in coprolitic masses probably attributable to *Dendrerpeton.* It is interesting to find reptilian life represented at this early period, not only by large and formidable species, but by diminutive forms, comparable with the smallest lizards and newts of the modern world. The fact is parallel with that of the occurrence of several small mammalian species in the mesozoic beds. It will be still more significant in this respect if the species of *Hylonomus* should be found to be truly lacertian rather than batrachian.

EXPLANATION OF PLATE VI, FIGS. 18 TO 31.

Hylonomus Wymani.

Fig. 18—Lower jaw with teeth, magnified.
" 19—Anterior part of lower jaw more magnified.
" 20—Portion of maxillary bone with teeth, magnified.
" 21—Maxillary bone, natural size.
" 22—Lower jaw, natural size.
" 23—Vertebræ, natural size.
" 24 and 25—Vertebræ, magnified.
" 26—Humerus, natural size and magnified.
" 27—Rib, natural size and magnified.
" 28—Pelvic bone, natural size and magnified.
" 29—Foot; the line shows the natural size.
" 30—Broken vertebra magnified, showing internal cavity.
" 31—Bony scales, natural size and magnified.

X.—HYLERPETON DAWSONI.

Plate VI, Figs. 32 to 46.

In the more or less laminated material which fills the interior of the erect trees of the Joggins, it often happens that the more distinctly separable surfaces are stained with ferruginous or coaly matter, or with fine clay, so that the fossils which occur on these surfaces, and which would otherwise be more available than those in more compact material, are rendered so obscure as readily to escape observation. This was unfortunately the case with one of the most interesting specimens contained in the last of these trees which I had an opportunity to examine. It consisted of the detached bones of a reptile scattered over a surface so blurred and stained that they escaped my notice until most of them were lost; and I was able to secure only a jaw bone and fragments of the skull, with a few of the other bones. On these fragments Prof. Owen founded the genus *Hylerpeton* and the species named at the head of this article. His description is as follows:

"This specimen consists of the left ramus of a lower jaw (Fig. 32), which has been dislocated from the crushed head, of which the fore end of the left premaxillary is preserved, terminating near the middle of the series of the teeth of the more advanced mandible. A fragment of the left maxillary, which has been separated from the premaxillary, overlaps the hinder mandibular teeth. The fore part of the mandible is wanting. The teeth in the remaining part are larger and fewer, in proportion to the jawbone, than in *Hylonomus* or *Dendrerpeton*. They have thicker and more obtusely terminated crowns; they are close-set where the series is complete at the fore part of the jaw, and their base appears to have been anchylosed to shallow depressions on the alveolar surface. The shape of what is preserved of the upper jaw affords the only evidence, and not very decisively, that the present fossil is not part of a fish. It inclines the balance, however, to the reptilian side; and, accepting such indication of the class-relations of the fossil, it must be referred to a genus of *Reptilia* distinct from those it is associated with in the Nova Scotian coal, and for which genus I would suggest the term *Hylerpeton*.

"A small part of the external surface of the dentary bone shows a longitudinally wrinkled and striate or fibrous character. The outer bony wall, broken away from the hinder half of the dentary, shows a large cavity, now occupied by a fine greyish matrix, with a smooth surface, the bony wall of which cavity has been thin and compact. We have here the mark of incomplete ossification, like that in the skeleton of *Archegosaurus*. The crushed fore part of the right dentary bone, with remains of a few teeth, is below the left dentary, and exemplifies a similar structure. The teeth slightly diminish, though more in breadth than length, towards the fore part of the series: here there are nine teeth in an alveolar extent of 10 millimeters, or nearly 5 lines. The base of the teeth is longitudinally fissured, but the fissures do not extend upon the exserted crown. In their general characters, the teeth manifest at least as close a resemblance to those of *Ganocephala* as of *Lacertia* or any higher group of *Reptilia*; whilst their mode of implantation, with the structure and sculpturing of the bone, weigh in favour of its relations to the lower and earlier order of the cold-blooded Vertebrates."

I can add to the above description only a few facts obtained from careful examination of other fragments imbedded in the matrix. One of these is a portion of a maxillary bone (Fig. 32). It has teeth similar to those of the lower jaw in form (Figs. 34 and 35), but the last but one is twice the size of the others, and seems to have been implanted in a deep socket. All of the teeth have large pulp cavities, and the inner surface of the ivory is marked with slight furrows which are represented by ridges on the outer surface of the stony matter filling the pulp cavities (Fig. 36). The ivory of the teeth, however, which is very much coarser than that of the species of *Hylonomus*, presents in the cross section a simple structure of radiating tubes (Fig. 37). The surface of the cranial bones, of which some fragments remain, is marked in the same striate manner alluded to above by Prof. Owen (Figs. 42, 43). The microscopic structure of the bone is much coarser than that of *Hylonomus* or *Dendrerpeton*, the cells being larger and in some portions less elongated (Fig. 46). That the creature had stout ribs is shown by the fragments represented in Fig. 40; but the vertebræ are represented only by a few bodies of small relative size and perhaps caudal (Figs. 38 and 39). On the same surface was found the foot represented in Fig. 44. It is of small size relatively to the head, and was probably for swimming rather than walking. A few ovate bony scales were found with the bones, and probably belonged to this species (Fig. 41).

On the whole it seems certain that *Hylerpeton* must have been generically distinct from the other reptiles found with it, and it is probable that it was of more aquatic habits, swimming rather than walking; and feeding principally on fish. More perfect specimens would however be required in order to warrant any decided statement on these subjects. It is possible, as suggested by Prof. Owen, that the affinities of the animal may be with *Archegosaurus* rather than with any of the other coal reptiles; but I confess that my present impression is that it tends rather toward the genus *Hylonomus*. It may possibly be a link of connection between the *Microsauria* and the *Archegosauria*.

EXPLANATION OF PLATE VI, FIGS. 32 TO 46.

Hylerpeton Dawsoni.

Fig. 32—Portion of maxillary bone with teeth.
" 33—Lower jaw and portions of skull.
" 34 and 35—Teeth magnified.
" 36—Cast of pulp cavity of a tooth.
" 37—Cross section of tooth magnified.
" 38 and 39—Bodies of Vertebræ.
" 40—Fragments of ribs.
" 41—Bony scale natural size and magnified.
" 42 and 43—Surface of bone magnified.
" 44—Foot.
" 45—Bone of same magnified.
" 46—Section of bone highly magnified.

XI.—Additional Reptilian Remains.

Plate VI, Figs. 47, 48, and 54 to 56.

Beside the species above described, Mr. O. C. Marsh, in 1861,* added a new animal to the Joggins reptilian fauna; the *Eosaurus Acadianus.* The species is founded on two large biconcave vertebræ, in many respects resembling those of *Ichthyosaurus*, and indicating a reptile of greater size than any hitherto discovered in the coal, probably of aquatic habits, and possibly allied to the great *Enaliosaurs* or sea lizards of the mesozoic rocks. The specimen was found in a bed of shale belonging to group XXVI of my Joggins section, in the upper part of the middle coal measures, and about 800 feet above the bed which has afforded the remains described in previous sections. The beds belong to one of those intervals of shallow water deposition of sediment, which separate the groups of coal beds; and on one of them I found some years ago the footprints of *Dendrerpeton.*

The vertebræ of *Eosaurus* have been fully and ably described by Mr. Marsh in Silliman's Journal. Agassiz and Wyman regard their affinities as enaliosaurian. Huxley suggests the possibility, founded on his recent discovery of *Anthracosaurus Russelli*, that there may have been *Labyrinthodont* batrachians in the coal period with such vertebræ. However this may be, if the vertebræ were caudal as supposed by Mr. Marsh, since they are about 2½ inches in diameter, they would indicate a gigantic aquatic reptile, furnished with a powerful swimming tail, and no doubt with apparatus for the capture and destruction of its prey, comparable with that of *Ichthyosaurus.*

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* The remains were discovered in 1855 though not published till 1861.

In a bed of hard calcareous sandstone, some distance below that which afforded the animal just noticed, there occur great numbers of teeth and scales, referable in part to large sauroid fishes, but perhaps also in part to reptiles. One of these is a remarkable tooth obtained by Sir W. E. Logan in 1843, and represented in Fig. 47. It resembles externally the teeth of *Baphetes*, but its structure is almost precisely that of the teeth of the *Lepidosteus*, or bony pike of the St. Lawrence. Another tooth from the same bed, and with a similarly fluted surface, has a more complex labyrinthic structure, as seen in Fig. 48, which however represents only a small fragment. With these occur large round thin scales like those of *Rhizodus*, but also wrinkled bony plates resembling that which I have attributed to *Baphetes.* From the hardness of the rock it is difficult to extract perfect specimens of these remains, and no bones other than teeth and dermal scales have been found.

Under this head may be noticed the coprolitic matter which not infrequently occurs with the remains of reptiles, in the erect trees of the Joggins, and to which reference has already been made in previous sections. This fossil excrement is of a brown or fawn colour, and consists in great part of carbonate of lime, indicating probably that shells of snails or other mullusks formed a considerable part of the food of the smaller reptiles of the coal swamps. Some portions of it are filled with small bones apparently of *Hylonomus Wymani.* Other examples contain abundance of fragments of chitinous matter referable in part to *Xylobius Sigillariæ*, the millipede of the coal; and in other instances to insects. Of the latter kind of remains the most interesting is an *Eye*, represented in Fig. 56. It must have belonged to an insect of considerable size, and with highly complex eyes, probably a neuropterous insect. As many as 250 facets are distinguishable in the fragment preserved, and the whole number in each eye may have amounted to 2000. In size and form the facets resemble those of the eye of a common Canadian dragon fly of the genus *Aeschna*, but are a little smaller. In this and other coprolites, though abundance of minute chitinous fragments remain, no others are sufficiently perfect to be recognized. In one coprolitic mass a quantity of thick crust or shell occurs, which under the microscope presents a minutely tubular and laminated appearance, resembling that of the shell of a crustacean rather than any other kind of structure with which I am acquainted. There may have been land-crabs in the coal period; but it is perhaps more likely that some one of the larger individuals of *Dendrerpeton* had been feeding on crustaceans in some pond or creek, before it fell into the pit in which it was entombed. It is however interesting to observe that no remains whatever of fishes have occurred in any of this coprolite or in the erect trees containing reptile bones, though such remains are very abundant in some of the associated beds. This fact confirms the inference deducible from other considerations, that the ground in which these open pits presented themselves, was not that of a very low swamp, liable to inundation, or very near to the sea or other bodies of water.

I may notice here certain very remarkable impressions, the origin of which I am at a loss to conjecture, but which may have had some relation to reptiles of the coal period. They occurred on the surface of a layer of grey sandstone about 60 feet above the bed containing the erect reptiliferous trees. This bed is one of a series of flaggy layers on which occur, with vegetable fragments, tracks, possibly of *Hylonomus*, and rain-marks. The impressions now referred to were thus described by me in 1861:

"They consist of rows of tranverse depressions, about an inch in length and one-fourth of an inch in breadth. Each trail consists of two of these rows running parallel to each other, and about six inches apart. Their direction curves abruptly, and they sometimes cross each other. From their position they were probably produced by a land or fresh-water animal—possibly a large Crustacean or gigantic Annelide or Myriapod. In size and general appearance they slightly resemble the curious *Climactichnites* of Sir W. E. Logan, from the Potsdam sandstone of Canada." To this I have only to add that the space between the rows of of marks is slightly depressed and smoothed, as if with a heavy body, like that of a serpent, trailed along.

I have given in Fig. 54, as a supplement to the history of *Dendrerpeton* and *Hylonomus*, a diagram of the form of the skull and the character of the dentition, restored from actual specimens This will serve further to illustrate the descriptions in previous sections.

In Fig. 65 I have represented a group of scales from the throat of *Dendrerpeton*, as they lie beside the skull from which the greater part of the details in Fig. 54 are taken. It will be seen that these are elongated, oval, and very closely imbricated in rows diverging in a pinnate manner from a mesial line. They would give much protection, while not deficient in flexibility. It is probable however that *Dendrerpeton* could breathe by other means than the gulping of air by the contraction of the throat; and would therefore be less dependent on the action of the gular muscles than the modern batrachians.

EXPLANATION OF PLATE VI, FIGS. 47, 48 AND 54 TO 56.

Additional Reptilian Remains.

Fig. 47—Tooth of unknown reptile or fish, natural size, section natural size, and portion of section magnified, showing infolding of the enamel and arrangement of the dentine.

" 48—Small segment of another tooth similar to the last in form and size, but more complex in the folding of the enamel.

" 54—Outer figure—Diagram of skull of *Dendrerpeton*, showing its size and general form, the appearance of the occipital condyles, and the arrangement of the double row of maxillary teeth and of the vomerine teeth.

" 54—Inner figure—Diagram of skull of *Hylonomus*, showing the arrangement of the single row of maxillary teeth and the patch of palatal teeth.

" 55—Bony scales of the throat of *Dendrerpeton Acadianum*, natural size.

XII. INVERTEBRATE AIR-BREATHERS.

Plate VI., Figs. 49 to 53, and 56 to 61.

In addition to the insect whose eye has already been noticed, but two species of land Invertebrates have been recognized in the coal of Nova Scotia. One of these is a snail, *Pupa vetusta*, the other a gally-worm or millepede, *Xylobius sigillariæ.* They are represented in the figures referred to at the head of this section, and have been fully described in the Journal of the Geological Society of London.

The first is the oldest known representative of the land snails, and so closely resembles the modern "chrysalis shells" of the genus *Pupa*, that I have not thought it desirable to refer it to a different genus, though the name *Dendropupa* has been proposed by Prof. Owen. Mr. J. S. Jeffreys and other eminent conchologists, who have seen the shell, concur in the opinion that it is a true *Pupa*; so that this genus, like Lingula and Nautilus, extends from the palæozoic to the modern times.

It may be described as a cylindrical shell, tapering to the apex, with a shining surface, marked with longitudinal rounded ridges. The whorls are eight or nine, rounded, and the width of each whorl is about half the diameter of the shell. The aperture is rather longer than broad; but is usually somewhat distorted by pressure. The margin of the lip is somewhat regularly rounded and is reflected outward. There are no teeth, but a slight indication of a ridge or ridges on the pillar lip, which may however be accidental. Length $\frac{3}{10}$ths of an inch or a little more. It was first recognized by Dr. Gould of Boston, in specimens obtained by Sir C. Lyell and the writer at the Joggins.

This little shell is remarkable, not merely for its great antiquity, but also because it is separated by so wide an interval of time from any other known species of its race, there being no other Pulmonate known until we reach the Purbeck beds, and no true land snail until we reach the Tertiary. It is also worthy of remark, that while hundreds of specimens have been found, not only in the erect reptiliferous trunks but in a bed 1217 feet lower, and separated by twenty-one coal beds, not any other species is found with it. It is very rare in modern times thus to find one species of snail in great abundance without any others. More especially is this so when we can examine, as in this case, not only the decayed trunks in which the creature sheltered itself, but also the beds of mud into which its dead shells were washed. These facts present a striking instance either of that "imperfection of the geological record", of which we hear so much, or of the solitary existence of a single species as a prophetic representative of future things, to be realized long after it had ceased to exist.

The lower bed, holding shells of *Pupa vetusta*, just mentioned, is a grey and greyish-blue under-clay, full of stigmarian rootlets, though without any coal or erect trees at its surface. It is 7 feet thick, with sandstone above and below. The shells occur very abundantly in a thickness of about two inches. They have been imbedded entire; but most of them have been crushed and flattened by pressure. They occur in all stages of growth; the young being, as is always the case in such shells, very different in general form from the adults. This bed is evidently a layer of mud deposited in a pond or creek, which afterward became silted up and carried sigillaroid trees. In modern swamps multitudes of shells occur in such places; and it is remarkable that in this case a single land shell should alone be found, without any trace of aquatic mollusks. The shells which occur in this bed are filled with the surrounding sediment. Those which occur in the erect *Sigillariæ*, on the other hand, except when they are crushed and flattened, are filled with a deposit of brown calc-spar. I infer from this that the latter when buried contained the animals, and consequently that these lived or sheltered themselves in the hollow trees, as is the habit of many modern land snails.

The gally-worm of the coal period, *Xylobius Sigillariæ*, must have existed in great numbers, as many layers in the erect trees are full of them. It probably lived in these decaying trunks just as its modern congeners do in similar places. As an air-breathing animal, and subsisting on vegetable food, it cannot have lived in water, or even in very wet places; and this is one of the evidences which in this case point to a greater dryness of the coal swamps than has hitherto been supposed probable; it also shows the resemblance of the conditions of the areas of coal accumulation to those of modern forests.

With regard to the affinities of *Xylobius*, its form and structure render certain its alliance with the Myriapods, and with the chilognathous division of them, or the gally-worms; but it is less certain to which of the families of the recent gally-worms it belongs, if to any of them. I have however little doubt that if it existed as a recent animal, it would go into the tribe *Bizonia* of Newport, and probably into the family of *Iulidæ*, to the typical genus of which it bears a strong resemblance in such points as can be made out. The oldest Myriapod previously known is, I believe, the *Geophilus proavus*, Münster, of the Jurassic period*.

EXPLANATION OF PL. VI, FIGS. 47 TO 53, AND 56 TO 61.

Invertebrate Air-Breathers.

Fig. 49.—*Pupa Vetusta*, natural size.
" 50.— " " magnified.

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* Pictet, Palæontologie, Vol. 11, p. 405.

Fig. 51.—*Pupa Vetusta*, apex magnified.
" 52.— " " sculpture of surface magnified.
" 53.— " " cellular structure of shell highly magnified.
" 56.—*Eye of an Insect*, natural size and magnified, and three ocelli highly magnified.
" 57.—*Xylobius Sigillariæ*, Anterior segments magnified.
" 58.— " " natural size.
" 59.— " " part of one of the posterior segments magnified.
" 60.— " " caudal extremity magnified.
" 61.— " " head magnified, showing the eyes.

XIII.—Characters of the Animals described in this paper.

To facilitate comparisons, I propose in this section to give an abstract of the leading structural points which may serve to distinguish the animals described in this paper from each other, and from such new species as may be discovered either in Nova Scotia or elsewhere. The characters given must necessarily be incomplete, and I shall confine myself to points distinctly ascertained and likely to be met with in any additional specimens which may be discovered.

Province.—VERTEBRATA.

Class.—Reptilia.

Order.—Microsauria.

Genus.—Hylonomus.

Reptiles or batrachians; with simple teeth in one series; biconcave vertebræ with arches anchylosed to them; ribs long and bent; limbs developed for walking; cranial bones smooth or nearly so; body protected below with oval or ovate bony scales, and above with horny scales and other appendages.

1. *Hylonomus Lyelli*, Dawson.—Teeth elongated, conical, thirty-six in each side of the jaw; larger toward the anterior part of the lower jaw; length of lower jaw .7 inch; limbs well developed, especially the posterior pair; bony scales oval; body above with imbricated horny scales, and rows of angular and bristly points.

2. *Hylonomus aciedentatus*, Dawson.—Teeth of maxillary and mandible thick wedge form, or nearly round at base and flattened to an edge at top. Teeth of intermaxillaries cylindric, bluntly

pointed, and with spiral furrows at the point. Number of teeth about forty on each side of jaw; length of lower jaw about 1 inch. Size more than twice that of *H. Lyelli.* Dermal covering so far as known, similar, but the parts large in proportion.

3. *Hylonomus Wymani*, Dawson.—Teeth obtusely conical, about twenty in each side of the jaw; length of lower jaw about .25 inch. Vertebræ elongated; size much smaller than that of *H. Lyelli.* Bony scales small and rounded, body above probably clothed in imbricated horny scales.

Order.—LABYRINTHODONTIA.

Genus.—BAPHETES.

Baphetes planiceps, Owen.—Teeth conical, hooked, striated longitudinally, and with inflected and convoluted cement; in two series; the inner of larger size. Cranial bones much corrugated. Head broad; breadth in front of orbits 6 inches; length from this line to front of snout 3½ inches. Probably a dermal covering of corrugated bony scales.

Genus.—DENDRERPETON.

Batrachians with a double series of teeth; the outer simple and flattened conic, the inner conical with inflected folds of cement. Teeth also on the vomer. Bones of skull corrugated; body protected below with long ovate or rhomboid bony scales, and above with imbricated horny scales. Form elongated, fore limbs largest, tail natatory, vertebræ biconcave, neural arches and bodies ossified.

1. *Dendrerpeton Acadianum*, Owen.—Inner teeth straight, conical; outer teeth short and obtuse. Length of head 2.75 inches, breadth at orbits about 2 inches, distance of orbits .7 inch. Length one to two feet.

2. *D. Oweni*, Dawson.—Teeth slender and hooked, and cement of inner teeth more perfectly inflected. Length of skull 1.2 inch, distance of orbits about .5 inch; length one foot or less.

Order.—ARCHEGOSAURIA?

Genus.—HYLERPETON.

Hylerpeton Dawsoni.—Owen.—Teeth simple, bluntly conical, with large pulp cavity; about 13 in one side of the jaw. Two of the anterior teeth of the upper jaw twice as large as the others.

and deeply sunk in the jaw. Length of lower jaw 1.3 inch Bones of skull puncto-striate. Limbs unknown, probably natatory.

SEDIS INCERTÆ.

Genus.—EOSAURUS.

Eosaurus Acadianus, Marsh.—Known by two biconcave vertebræ 2.4 inches in diameter and much resembling the caudal vertebræ of *Ichthyosaurus*—see paper by Mr. Marsh, Silliman's Journal, vol. xxxiv.

Province.—ARTICULATA.

Sub Class.—MYRIAPODA,

Order.—CHILOGNATHA.

Genus.—XYLOBIUS.

Xylobius Sigillariæ.—Dawson.—Body crustaceous, elongate, one to two inches in length, articulate; when recent, cylindrical or nearly so, rolling spirally. Feet small, numerous; segments 30 or more; anterior segments smooth, posterior with transverse wrinkles, giving a furrowed appearance. In some specimens traces of a series of lateral pores or stigmata. Labrum? quadrilateral, divided by notches or joints into three portions. Mandibles two-jointed, last joint ovate and pointed. Eyes ten or more on each side.

Province.—MOLLUSCA.

Class.—GASTEROPODA.

Order.—PULMONATA.

Genus.—PUPA.

Pupa Vetusta.—Dawson.—Cylindrical, tapering toward the apex; surface shining, minutely marked with longitudinal ridges; whorls 8 or 9, rounded, width of each equal to half the diameter of the shell; aperture rather longer than broad; outer lip regularly rounded and somewhat reflected; pillar lip straightened above, rounded below. Edentulous or with faint ridges on columella? Length .3 inch or a little more.

XIV.—CONCLUDING REMARKS.

Having finished the work which I proposed to myself, in illustration of the air-breathers of the coal period in Nova Scotia, it now remains to mention a few general thoughts which have arisen in connection with the animals which have been described.

I have endeavored, in the frontispiece, to present to the eye the forms and attitudes of these creatures. In doing so as little latitude as possible has been allowed to the imagination, and the structural points indicated by the bones and skin actually found, have been adhered to as closely as practicable. On the left hand *Baphetes planiceps* is seen emerging with a ganoid fish in its jaws. Next *Dendrerpeton Acadianum* is represented slowly walking up the inclined shore, and leaving its hand-like footprints thereon. A little farther up *Hylonomus Lyelli* is leaping in pursuit of an insect, and *Hylonomus Wymani* stands a little more in the foreground, while *Hylerpeton Dawsoni* is disporting itself in the water in front. I am quite aware that the form and action given to *Hylonomus* are at variance with the views of its nature which would ally it with *Archegosaurus;* but, as stated above, I cannot refuse my belief to the testimony of the bones themselves, which prove a development of the hind limbs not likely to have been associated with an elongated body and natatorial tail, and pointing to saltatory motion on land, and perhaps frog-like swimming in the water. In the middle ground of the picture I have placed a bank of soil, showing a section of a hollow trunk similar in situation to those in which the reptile bones of the Joggins occur, and on this bank and in the distance, I have endeavored to give some of the characteristic forms of the vegetation of the period: Ferns, *Cordaites*, *Sigillaria*, *Lepidendron*, *Lepidophloios*, and *Calamites*.

It has recently been a favorite view with some writers on this subject, that coal beds may have been formed in shallow salt water, and that *Sigillariæ* may have grown in such places, like mangroves. It will be seen from the frontispiece, that I do not believe in this theory of the formation of coal, but on the contrary adhere to the opinion which I have formerly maintained, that the coal beds and under-clays are of the nature of peaty soils. In no part of the world are the coal measures better developed or more fully exposed than in the coast sections of Nova Scotia and Cape Breton, and in these, throughout their whole thickness, no indication has been found of any of the marine fossils of the lower carboniferous limestone. Abundant remains of fishes occur, but these may have frequented estuaries, streams and ponds, and the greater part of them are small ganoids which, like the modern *Lepidosteus* and *Amia*, may have been specially fitted by their semi-reptilian respiration, for the impure waters of swampy regions. Bivalve mollusks also abound; but these are all of the kinds to which I have given the generic name *Naiadites*, and Mr. Salter those of *Anthracomya* and *Anthracoptera.* These shells are all distinct from any known in the marine limestones. Their thin edentulous valves, their structure consisting of a wrinkled epidermis, a thin layer of prismatic shell and an inner layer of sub-nacreous shell composed of obscure polygonal cells, all remind us of the Anodons and Unios.* A slight notch in front, noticed by Salter, as possibly byssal, concurs with their mode of occurrence in rendering it probable that, like mussels in modern estuaries, they attached themselves to floating or sunken timber. They are thus removed, both in structure and habit, from truly marine species; and if not actually of the family *Unionidæ*, must have been fresh-water or brackish-water mussels closely allied to this family. The crustaceans (*Eurypterus*, *Diplostylus*, *Cyprids*,) and the worm shell (*Spirorbis*)† found with them, are not necessarily marine, though some of them belonged probably to brackish water, and they have not yet been found in those carboniferous beds deposited in the open sea. There is thus in the whole thickness of the middle coal measures of Nova Scotia, a remarkable absence at least of open sea animals; and if, as is quite probable, the sea inundated at intervals the areas of coal accumulation, the waters must have been shallow and to a great extent land-locked, so that brackish-water rather than marine animals inhabited them.

On the other hand, there are in these coal measures, abundant evidences of land surfaces; and sub-aeriel decay of vegetable matter in large quantity is proved by the occurrence of the mineral charcoal of the coal itself, as I have elsewhere shown.* The erect trees which occur at so many levels, also imply sub-aerial decay. A tree imbedded in sediment and remaining under water, could not decay so as to become hollow and deposit the remains of its wood in the state of mineral charcoal within the hollow bark. Yet this is the case with the greater part of the erect sigillariæ which occur at more than 20 levels in the Joggins section. Nor could such hollow trunks become repositories for millipedes, snails and reptiles, if under water. On the other hand, if, as seems necessary to explain the character of the reptiliferous erect trees, these remained dry or nearly so in the interior, this would imply not merely a soil out of water, but comparatively well drained; as would indeed always be the case, when a flat resting on a sandy subsoil was raised several feet above the level of the water. Farther, though the peculiar character of the roots of *Sigillariæ* and *Calamites* may lend some countenance to the supposition that they could grow under water or in water-soaked soils, this will not apply to coniferous trees, to ferns, and other plants, which are found under circumstances which show that they grew with the *Sigillariæ.*

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* The microscopic structure of these shells is well preserved, and presents some differences of detail which I hope at a future time to illustrate.

† The idea of some Palæobotanists, that these so-called Spirorbes are fossil parasitic plants, is obviously a mistake. They are calcareous shells, and present under the microscope a prismatic cellular structure, with numerous minute tubuli, in the manner of the shells of modern *Serpulæ* and *Spirorbes.* In Nova Scotia I have seen *Estheriæ* only in the lower coal formation.

In the coal measures of Nova Scotia, therefore, while marine conditions are absent, there are ample evidences of fresh-water or brackish-water conditions, and of land surfaces, suitable for the air-breathing animals of the period. Nor do I believe that the coal measures of Nova Scotia were exceptional in this respect. It is true that in Great Britain evidences of marine life do occur in the coal measures; but not, so far as I am aware, in circumstances which justify the inference that the coal is of marine origin. Alternations of marine and land remains, and even mixtures of these, are frequent in modern submarine forests. When we find, as at Fort Lawrence in Nova Scotia, a modern forest rooted in upland soil forty feet below high-water mark,† and covered with mud containing living Tellinas and Myas, we are not justified in inferring that this forest grew in the sea. We rather infer that subsidence has occurred. In modern salt marshes it is not unusual to find every little runnel or pool full of marine shellfish, while in the higher parts of the marsh land plants are growing;

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* Journal of Geological Survey, vol. XV.

† Journal of Geological Society, vol. XI

and in such places the deposit formed must contain a mixture of land plants and marine animals with salt grasses and herbage—the whole *in situ.*[*]

These considerations serve, I think, to explain all the apparently anomalous associations of coal plants with marine fossils; and I do not know any other arguments of apparent weight that can be adduced in favor of the marine origin of coal, except such as are based on misconceptions of the structure and mode of growth of sigillaroid trees and of the stratigraphical relations of the coal itself.[†] It is to be observed, however, that while I must maintain the essentially terrestrial character of the ordinary coal and of its plants, I have elsewhere admitted that cannel coals and earthy bitumen present evidences of sub-aquatic deposition; and have also abundantly illustrated the facts that the coal plants grew on swampy flats, liable not only to river inundations, but also to subsidence and submergence.[‡] In the oscillation of these conditions it is evident that *Sigillariæ* and their contemporaries must often have been placed in conditions unfavorable or fatal to them, and when their remains are preserved to us in these conditions, we may form very incorrect inferences as to their mode of life.

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[*] In the marshes at the mouth of Scarborough River, in Maine, channels not more than a foot wide, and far from the sea, are full of Mussels and Myæ; and in little pools communicating with these channels there are often many young *Limuli,* which seem to prefer such places, and the cast off shells and other remains of which many become imbedded in mud and mixed with land plants, just as in the shales of the coal measures.

[†] It is unfortunate that few writers on this subject have combined with the knowledge of the geological features of the coal, a sufficient acquaintance with the phenomena of modern marshes and swamps, and with the conditions necessary for the growth of plants such as those of the coal. It would be easy to show, were this a proper place to do so, that the "swells," "rock-faults," splitting of beds, and other appearances of coal seams, quite accord with the theory of swamp accumulation; that the plants associated with *Sigillariæ* could not have lived with their roots immersed in salt water; that the chemical character of the under-clays implies drainage and other conditions impossible under the sea; that the composition and minute structure of the coal are incompatible with the supposition that it is a deposit from water, and especially from salt water; and that it would be more natural to invoke wind-driftage as a mode of accumulation for some of the sandstones, than water-driftage for the formation of the coal.

[‡] Journal of Geol. Socy., vols. X and XV and "Acadian Geology."

Farther, it is be observed that the conditions of submergence and silting up which were favorable to the preservation of specimens of *Sigillariæ* as fossils, must have been precisely those which were destructive to them as living plants; and on the contrary that the conditions in which these forests may have flourished for centuries, must have been those in which there was little chance of their remains being preserved to us, in any other condition at least than that of coal, which reveals only to careful microscopic examination the circumstances, whether aerial or aquatic, under which it was formed.

It is also to be observed that, in conditions such as those of the coal-formation, it would be likely that some plants would be specially adapted to occupy newly emerged flats and places liable to inundation and silting up. I believe that many of the *Sigillariæ*, and still more eminently the *Calamites*, were suitable to such stations. There is direct evidence that the nuts of *Sigillariæ* (Trigonocarpa) were drifted extensively by water over submerged flats of mud. Many *Cardiocarpa* were winged seeds which may have drifted in the air. The Calamites may, like modern *Equiseta*, have produced spores with elaters capable of floating them in the wind. One of the thinner coals at the Joggins is filled with spores or spore-cases that seem to have carried hairs on their surfaces, and may have been suited to such a mode of dissemination. I have elsewhere proved that at least some species of *Calamites*, were by their mode of growth admirably fitted for growing amid accumulating sediment and for promoting its accumulation.

These and other facts to be ascertained only by a careful and minute study of the coal formation and its fossils, are essential to a right understanding of the complicated conditions involved in the growth of these great deposits; and notwithstanding the immense mass of facts which has been collected, there is still no department of geology more encumbered with crude hypotheses and hasty generalizations, than that which relates to the history of the carboniferous period.

The reptiles of the coal formation are probably the oldest known to us, and possibly, though this we cannot affirm, the highest products of creation in this period. Supposing, for the moment, that they are the highest animals of their time, and what is still less likely, that those which we know are a fair average of the rest, we have the curious fact that they are all carnivorous, and the greater part of them fitted to find food in the water as well as on the land. The plant feeders of the period, on the land at least, are all invertebrates, as snails, millepedes, and perhaps insects. The air-breathing vertebrates are not intended to consume the exuberant vegetable growth, but to check the increase of its animal enemies. Plant life would thus seem to have had in every way the advantage. The millepedes probably fed only on roots and decaying substances—the snails on the more juicy and succulent plants growing in the shadow of the woods. While, moreover, the vegetation of the coal swamps was most abundant, it was not, on the whole, of a character to lead us to suppose that it supported many animals. Our knowledge of the flora of the coal swamps is sufficiently complete to exclude from them any abundance of the higher phænogamous plants. We know little, it is true, of the flora of the uplands of the period; but when we speak of the coal formation land, it is to the flats only that we refer. The foliage of the plants on these flats, with the exception of that of the ferns, was harsh and meagre, and there seem to have been no grasses or other nutritious herbaceous plants. These are wants of themselves likely to exclude many of the higher forms of herbivorous life. On the other hand there was a profusion of large nut-like seeds, which in a modern forest would probably have afforded subsistence to squirrels and similar animals. The pith and thick soft bark of many of the trees must at certain seasons have contained much nutritive matter, while there was certainly sufficient material for all those insects whose larvæ feed on living and dead timber, as well as for the creatures that in turn prey on them. It is remarkable that, perhaps with the exception of a very few European insects, no animals fitted to avail themselves of these vast stores of food have been discovered in the coal. The question: "What may have fed on all this vegetation?" was never absent from my mind in all my explorations of the Nova Scotia coal sections; but no trace of any creature other than those already mentioned has ever rewarded my search. In Nova Scotia it would seem that a single snail and a single gally-worm were the sole links of connection between the plant creation and air-breathing vertebrates. Is this due to the paucity of the fauna, or the imperfection of the record? The fact that a few erect stumps have revealed nearly all the air-breathers yet found, argues strongly for the latter cause; but there are some facts bearing on the other side.

Our gally-worm, if, like its modern relatives, hiding in crevices of wood in forests, was one of the least likely animals to be found in aqueous deposits. The erect trees gave it its almost sole chance of preservation. *Pupa vetusta* is a small species, and its shell very thin and fragile, while it probably lived among thick vegetation. Further it occurs in great abundance in the sigillaria stumps, and also in a bed separated from these by a thickness of 1217 feet, including 21 coal seams, having an aggregate thickness of about 20 feet, 3 beds of bituminous limestone of animal origin, and perhaps 20 beds holding *Stigmaria* in situ, or *erect Sigillariæ* and *Calamites.* The lapse of time implied by this succession of beds, many of them neccessarily of very slow deposition, must be very great, though it would be mere guess work to attempt to resolve it into years. Yet long though this interval must have been, *Pupa vetusta* lasted without one iota of change through it all; and more remarkable still, was not accompanied by any other mollusk of its family. Where so many specimens occur, and in situations so diverse, without any additional species, the inference is strong that no other of similar habits existed. If in any of those sub-tropical islands, whose climate and productions somewhat resemble those of the coal period, after searching in and about decaying trees, and also on the bars upon which rivers and lakes drifted their burdens of shells, we should find only a single species, but this in very great numbers, we would surely conclude that other species, if present, were very rare.

Again, footprints referrible to *Dendrerpeton* occur in the lower coal measures below the marine limestones, in the middle coal measures, and in the upper coal formation, separated by a thickness of beds which may be estimated at 15,000 feet, and certainly representing a vast lapse of time. Did we know the creature by these impressions alone, we might infer its continued existence for all this great length of time; but when we also find its bones in the principal repositories of reptile remains, and in company with the other creatures found with it, we satisfy ourselves that of them all it was the most likely to have left its trail in the mud flats. We thus have reason to conclude that it existed alone during this period, in so far as its especial kind of habitat was concerned; though there lived with it other reptiles, some of which, haunting principally the woods, and others the water, were less likely to leave impressions of their footprints. These may be but slight indications of truth, but they convey strong impressions of the persistence of species, and also of the paucity of species belonging to these tribes at the time.

Every fact of this kind is at present regarded in its bearings on the probable origin of species, and on the questions of independent creation or of derivation by natural selection, or by some other secondary law. Naturalists have set themselves to discover the philosopher's stone which can transmute the viler into the more exalted species. They will probably fail as others have failed before, but may at least hope to elicit some law of succession or occurrence of living creatures, and to settle more clearly than heretofore what should be regarded as natural species, as distinct from mere races and varieties. It may perhaps be found, after all, that the question whether the creative force manifested itself in calling certain species into existence from nothing, from dead matter, or from previously organized matter, whether by an instant and miraculous act, by more sudden natural change, or by slow and gradual processes, is insoluble by us; or that all or many of these modes may have been concerned in making living beings what they are; but of this every sound thinker must be convinced, that if not originating in distinct creative acts, species as we have them must be due to causes vastly more recondite and complex than the present advocates of derivation suppose. Nor can even the transmutationist altogether get rid of the miracle of creation; though he may push it back to as great a distance as possible. Some creative force must always precede law, and this even when the theorist goes so far as to derive all things from a concourse of atoms; or, more venturous still, dispenses even with atoms, and resolves all that he knows into an aggregate of conflicting yet mutually convertible forces. It is scarcely to be supposed that any member even of this last school, will choose to plunge into the two-fold absurdity of supposing that forces are themselves produced by nothing but the law of their own action, and produce all things by their action on nothing but themselves.

If we could affirm that the air-breathers of the coal period were really the first species of their several families, they might acquire additional interest by their bearing on this question of origin of species. We cannot affirm this; but it may be a harmless and not uninstructive play of fancy to suppose for a moment that they actually are so, and to inquire on this supposition as to the mode of their introduction. Looking at them from this point of view, we shall first be struck with the fact that they belong to all of the three great leading types of animals which include our modern air-breathers—the Vertebrates, the Articulates, and the

Mollusks. This at once excludes the supposition that they can all have been derived from each other, within the limits of the coal period. No transmutationist can have the hardihood to assert the convertibility, by any direct method, of a snail into a millipede, or of a millipede into a reptile. The plan of structure in these creatures is not only different but contrasted in its most essential features. It would be far more natural to suppose that these animals sprang from aquatic species of their respective types. We should then seek for the ancestors of the snail in aquatic gasteropods, for those of the millipede in worms or crustaceans, and for those of the reptiles in the fishes of the period. It would be easy to build up an imaginary series of stages, on the principle of natural selection, whereby these results might be effected; but the hypothesis would be destitute of any support from fact, and would be beset by more difficulties than it removes. Why should the result of the transformation of water snails breathing by gills be a *Pupa*? Would it not much more likely be an *Auricula* or a *Limnea*? It will not solve this difficulty to say that the intermediate forms became extinct and so are lost. On the contrary they exist to this day, though they were not, in so far as we know, introduced so early. But negative evidence must not be relied on; the record is very imperfect, and such creatures may have existed though unknown to us. It may be answered that they could not have existed in any considerable numbers, else some of their shells would have appeared in the coal formation beds, so rich in crustaceans and bivalve mollusks. Further, the little Pupa remained unchanged during a very long time, and shows no tendency to resolve itself into anything higher or to descend to anything lower. Here, if anywhere, in what appears to be the first introduction of air-breathing invertebrates, we should be able to find the evidences of transition from the gills of the prosobranchiate and the crustacean to the air sac of the pulmonate and the tracheæ of the millipede. It is also to be observed that many other structural changes are involved, the aggregate of which makes a pulmonate or a millipede different in every particular from its nearest allies among gill-bearing gasteropods or crustaceans.

It may be said however that the links of connection between the coal reptiles and the fishes are better established. All the known coal reptiles have leanings to the fishes in certain characters; and in some, as in *Archegosaurus*, these are very close. Still the interval to be bridged over is wide and the differences are by no means those which we should expect. Were the problem given to convert a ganoid fish into an *Archegosaurus* or *Dendrerpeton*, we should be disposed to retain unchanged such characters as would be suited to the new habits of the creature, and to change only those directly related to the objects in view. We should probably give little attention to differences in the arrangement of skull bones, in the parts of the vertebræ, in the external clothing, in the microscopic structure of the bone, and other peculiarities for serving similar purposes by organs on a different plan, which are so conspicuous so soon as we pass from the fish to the batrachian. It is not in short an improvement of the organs of the fish that we witness so much as the introduction of new organs. The foot of the batrachian, bears perhaps as close a relation to the fin of the fish as the screw of one steamship to the paddle wheel of another, or as the latter to a carriage wheel; and can be just as rationally supposed to be not a new instrument but the old one changed.

Again, our reptiles of the coal do not constitute a continuous series, nor is it possible that they can all, except at widely different times, have originated from the same source. To suppose that *Hylonomus* grew out of *Dendrerpeton* or *Baphetes*, and *Eosaurus* out of either, startles us almost as much as to suppose that *Baphetes* grew out of *Rhizodus*, or *Hylonomus* out of *Palæoniscus*. It either happened, for some unknown reason, that many kinds of fishes put on the reptilian guise in the same period, or else the vast lapse of ages required for the production of a reptile from a fish, must be indefinitely increased for the production of many dissimilar reptiles from each other; or on the other hand we must suppose that the limit between the fish and reptile being once overpassed, a facility for comparatively rapid changes became the property of the latter. Either supposition would, I think, contradict such facts bearing on the subject as are known to us.

We commenced with supposing that the reptiles of the coal might possibly be the first of their family, but it is evident from the above considerations, that on the doctrine of natural selection, the number and variety of reptiles in this period would imply that their predecessors in this form must have existed from a time earlier than any in which even fishes are known to exist; so that if we adopt any hypothesis of derivation, it would probably be necessary to have recourse to that which supposes at particular periods a sudden and as yet unaccountable transmutation of one form into another; a view which in its remoteness from anything included under ordinary natural laws, does not materially differ from that currently received idea of creative intervention, with which, in so far as our coal reptiles can inform us, we are for the present satisfied.

There is one other point which strikes the naturalist in considering these animals, and which has a certain bearing on such hypothesis. It is the combination of various grades of reptilian types in these ancient creatures. It has been well remarked by Hugh Miller, and more fully by Agassiz, that this is characteristic of the first appearance of new groups of animals. Now selection, as it acts in the hands of the breeder, tends to specialization; and natural selection, if there is such a thing, is supposed to tend in the same direction. But when some distinctly new form is to be introduced, an opposite tendency seems to prevail, a sort of aggregation in one species of characters afterward to be separated and manifested in distinct groups of creatures. The introduction of such new types also tends to degrade and deprive of their higher properties previously existing groups of lower rank. It is easy to perceive in all this, law and order in that higher sense in which these terms express the will and plan of the Supreme Mind, but not in that lower sense in which they represent the insensate operation of blind natural forces.

Humble though the subjects of this paper are, we see in them the work of Supreme Intelligence, introducing new types upon the scene and foreshadowing in them those higher forms afterward to be created. It is this, their Divine origin, and the light which they throw on the plan and order of the creative work, of which we ourselves form a part, that gives them all their interest to us. They are the handiwork of our Father and our God, traces of his presence in primeval ages of the earth, evidences of the unity of his plan and pledges of its progressive nature; adding their feeble voices to the testimony of revelation in respect to the history of creation in its earlier stages, and to the carrying on of that plan which still involves the extinction of many things from the present world, and the elevation of others into new and glorious manifestations. Their place in the system of nature and in the order of the world's progress, their uses in their own time and their relations to other beings as parts of the great cosmos, are the points that chiefly interest us: and if any one desires to understand more in detail, how they were created, we wish him all success in his inquiries, but warn him not to suppose that this great mystery is to be solved by a reference merely to material agencies apart from that Spiritual Power who is the essence of forces, the origin of laws.

ART. XXII.—*On the Origin of Eruptive and Primary Rocks.* By THOMAS MACFARLANE. *Part I.*

(Presented to the Natural History Society.)

On a former occasion,* I had the honor of presenting to this Society a series of papers describing the primitive formations as they occur in Norway, and comparing them with their Canadian equivalents. I then confined myself to a simple statement of the facts known regarding these formations, referring to their constituent rocks, to their structure, and to the order of their succession, but abstaining altogether from any attempt to propound a theory which might explain the various phenomena described. I subsequently † however gave a translation of a chapter from Naumann's classical *Lehrbuch der Geognosie*, wherein the various views entertained by geologists as to the origin of these formations, are plainly and impartially stated. It there appears, that although there exists an extraordinary diversity of opinion among geologists on this subject, there are two distinct and opposing theories, under one or other of which those different views may be classified. The first of these theories, and the one adopted by the majority of geologists, supposes the primitive or primary rocks to have resulted from the alteration or metamorphism of sedimentary strata. The second theory supposes them, in part at least, to represent the first solidified crust of our planet.

Although these opposing theories might with justice be respectively termed, so far as they refer to the origin of the primary rocks, the aqueous or metamorphic theory, and the igneous theory, still they must not be considered as bearing the slightest relation to the old theories adopted, and so pertinaciously argued by the neptunists and plutonists. The question in dispute then, referred to the origin of the undoubtedly intrusive and unstratified rocks,—granite, porphyry, basalt, &c. So far however as concerns the primitive stratified rocks, Werner and Hutton both regarded them as of sedimentary origin, although they differed as to the state in which they were deposited; and Hutton alone considered it necessary to explain their crystalline condition by the metamorphic action of heat. Indeed, instead of there being any analogy between the old controversy and the present question, it happens that Hutton, the founder of the plutonic school of former days, was the originator of the theory at present prevailing of the aqueous origin of the primary stratified rocks.

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* Canadian Naturalist, Vol. VII, p. 1.

† Canadian Naturalist, Vol. VII, p. 254.

On the other hand, it is scarcely possible to say who was the author of the igneous theory, although the writings in which it was propounded are of comparatively recent date. Probably among its earliest supporters was Sir H. T. De la Beche, who thus expresses himself on the subject:—"If we consider our "planet as a cooling mass of matter, the present condition of "its surface being chiefly due to such a loss of its original heat "by long continued radiation into the surrounding space, that "from having been wholly gaseous, then fluid and gaseous, and "subsequently solid, fluid and gaseous, the surface at last became "so reduced in temperature, and so little affected by the remaining internal heat, as to have its temperature chiefly regulated "by the sun, there must have been a time when solid rock was "first formed, and also a time when heated fluids rested upon it. "The latter would be conditions highly favorable to the production of crystalline substances, and the state of the earth's "surface would then be so totally different from that which now "exists, that mineral matter even abraded from any part of the "earth's crust which may have been solid, would be placed under "very different conditions at different periods. We could scarcely "expect that there would not be a mass of crystalline rocks "produced at first, which, however they may vary in minor "points, should still preserve a general character and aspect, the "result of the first changes of fluid into solid matter, crystalline "and sub-crystalline substances prevailing, intermingled with "detrital portions of the same substances, abraded by the movements of the heated and first formed aqueous fluids." *

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* Report on the Geology of Cornwall, &c., p. 32.

Although this language is somewhat indefinite, still the idea embodied in the igneous theory is shadowed forth in it, and on the whole this quotation may be considered as the text of the present essay. It is I believe possible to maintain, with every appearance of reason, that the Primitive Gneiss formation constitutes the first solidified crust of the originally fused globe, and that the crystalline and sub-crystalline rocks of the Primitive Slate formation are the products of a peculiar transition period, during which aqueous fluids gradually accumulated on the surface, and the latter attained a temperature approaching somewhat to that of the present day.

In attempting to show that this proposition is supported by geological evidence, I shall confine myself principally to arranging and elaborating the facts and arguments in support of it, which I have found scattered through a considerable number of geological papers and manuals. I shall also, in order to state the case with full force, be obliged to insert prefatorily much of what may be considered as mere elementary facts in physical geography and geology. I shall first refer to the evidences which we possess regarding the internal heat of our planet and its density, deducing from them certain conclusions as to the present condition of the interior of the earth. In doing so, I shall allude to the nature of certain volcanic products; and then continuing the considerations of the constitution and mode of occurrence of igneous rocks, I shall search back through the various eruptive formations for evidences of the nature of the igneous action which has taken place in former periods of the earth's history, and ultimately arrive at the consideration of the theory of the earth's original state of igneous fluidity. This theory, universally admitted by geologists, will then afford us a firm starting point for some speculations as to the process of the first solidification of the earth's crust, and the origin of gneissoid rocks. Pursuing the subject further, I shall endeavour to shew that the peculiar rocks of the Primitive Slate formation are also products of the action of the first condensed fluids on the heated crust of the earth. There are few theories whereon such a unanimity of opinion exists among geologists, as that of the originally fused condition of our planet, and few formations regarding the origin of which more uncertainty prevails than that of the primitive formations. If therefore it can be shewn to be probable that these primitive formations have merely resulted from an originally fused globe in the process of cooling, much will have been done toward filling up a great gap in the history of the earth's development.

I. The Temperature and Density of the Interior of our Planet.

It will no doubt seem to many that the matters to be treated of in this chapter, are far beyond the limits of the subject of the present paper. Since, however, the originally fused condition of our planet, and the constitution of its mass, are at the foundation of the igneous view of the origin of the primitive gneiss formation, it would seem necessary to refer to the reasonings upon which the idea of a fused globe, and the various theories propounded regarding the structure of the interior of our planet, are based. Many of these reasonings are founded on phenomena observable at the present day, which point to the existence of intense heat and extraordinary density in the centre of the earth. Hence this proposed recapitulation of the evidences of internal heat and density may not be out of place.

Whatever may have been the temperature of the earth's surface in the former periods, it is abundantly evident that it is now altogether regulated by the sun. Since the influence of the sun's rays penetrates to some extent beneath the surface, and affects the degree of temperature there existing, it will be necessary to define the extent to which this takes place, before proceeding to advert to the influence of the subterranean heat on the temperature of the earth's crust. It is obvious that the influence of the sun's rays is exerted very irregularly, and that variations in the degree to which the surface of the earth is affected by it occur throughout the day, and annually. The diurnal variations are of course not so great as those of the year, and the latter vary of course with the situation of the point of observation. These diurnal and annual variations are less and less felt, the deeper, to a certain point, we penetrate beneath the surface. Towards this point the extremes of temperature gradually approach nearer to each other, the differences are gradually equalized, and finally they disappear completely. The depth at which this point of constant temperature exists varies with latitude and climate, and with the capacity for conducting heat which the surface possesses. In African deserts, where the sand has been found to possess sometimes a temperature of 40° to 48°

R,[*] the point of constant temperature is near the surface, because the annual variations are comparatively small. The average temperature of the warmest month in Singapore is 22.40 ° R., of the coldest month 20.6 ° R.[†] The yearly variation therefore, does not exceed 1.8 ° R., and consequently the point where the extremes equalize themselves must be very near the surface. In higher latitudes however, where the variations are greater, (London 11.80 ° R., Paris 13.50 ° R., New York 21.70 ° R.,) the point of invariable temperature lies deeper. In the temperate zone, the daily variations disappear at a depth of from three to five feet, and the annual variations at a depth of from 60 to 80 feet beneath the surface. The celebrated thermometer placed 86 feet beneath the surface in the vault of the national observatory at Paris in 1783, shews constantly a temperature of 9.60 ° R.[‡] Since the average temperature of Paris is 8.60 ° R., it would therefore appear that even at this depth of 86 feet the influence of the central heat begins to make itself felt.

As early as the year 1678, the Jesuit Athanasius Kircher was informed by Hungarian miners that a higher temperature existed in the depths of mines, than on the surface of the earth, and Von Trebra, in 1785, mentions the same fact.[§] Not only was practical experience of the existence of a subterranean source of heat first obtained by miners, but the first experiments made with the view of ascertaining the temperature of the earth's crust at greater depth, were instituted in mines. The results of these experiments constituted for a long time the only proofs of the increase of the temperature with the depth. It cannot be denied however that the observations made in the shafts and underground working of mines are subject to various disturbing influences, so that it would appear that at least the earliest of these observations are less to be relied upon than those from other sources. But since they shew a general coincidence they furnish, when taken in connection with other observations, a complete confirmation of the fact of the increase of temperature with the depth. The results of the experiments instituted in mines, differ in value according as they have reference to the temperature of the air, water or rock there occurring. Those obtained from observations made on the rock plainly deserve most confidence.* Not only in European mines, but in those of South America, Mexico, the United States, and the East Indies, observations have proved that the temperature increases with the depth, and shewn that it remains invariable at one and the same depth, provided no disturbing causes are at work. In 1740, Gensanne instituted experiments at Giromagny in the Vosges which gave the following results :—At a depth of

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[*] Pouillet; Muller, Lehrbuch der Physik and Meteorologie, Vol II, p. 724.

[†] Ibid II, 716.

[‡] Quenstedt, Epochen der Natur, p. 13.

[§] Ibid p. 12.

339 feet the temperature was........12.5°. Centigrade.
634 " " " ....13.1° "
948 " " " ....19.0° "
1333 " " " ....22.7° "

Saussure obtained the following results at Bex in the Canton Waadt, in a shaft in which no one had been for three months previously.

Depth.	Temperature.	
322	14.4°	Centigrade.
564	15.6°	"
677	17.4°	"

Similar observations were afterwards made in the mines of Freiberg by d'Aubuisson, Von Humboldt, and Von Trebra; in the mines of Cornwall by Forbes, Fox, and Barkam, and in the Anzasca valley by Fontanetti. The most comprehensive and exact observations were however those made at the instance of the government mining officials of Saxony and Prussia, in the mines of those countries. The observations in the Prussian mines led to the following results.†

1. That a decided increase of temperature takes places with increase of depth.
2. That the temperature at every greater depth is invariable, since the annual oscillations were at the most only 1°.
3. That the depth corresponding to an increase of temperature of 1°, differs extremely in different localities, varies from 48 to 355 feet, and on an average amounts to 167 feet.
4. That the temperature increases twice as rapidly in coal mines as in ore mines.

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* Naumann, Lehrbuch der Geognosie, I, 49.

† Poggend. Ann; vol. xxii, 1831, p. 497.

5. That the observations did not afford data sufficiently decided for the establishment of any law as to the progression of the increase of temperature.

The experiments instituted in the Saxony mines were under th careful direction of Reich, and made with very good thermometers, sunk forty inches into the solid rock, and with every possible precaution. They yielded the following results.[*]

1. That the temperature increases decidedly with the depth.
2. That the temperature is invariable at every one point of observation.
3. That the average distance, corresponding to an increase of one degree Reaumur in temperature, is 129 feet.
4. That a general law with regard to the relative increase of temperature cannot be deduced from these experiments.
5. That the rock in the underground workings and in the course of time becomes somewhat cooled by the air of the mine, and that on the whole the cooling influences overbalance the heating ones.

Among other observations the following may be mentioned:— The distance corresponding to an increase of temperature of one degree was determined by:

Oldham in Waterford, Ireland, as	165	Feet.
Phillips in New Castle	100	"
Hodgkinson in Manchester	115	"
Hinzeau in Belgium	102	"
Cordier near Canneaux	111	"[†]

It will be observed that in the observations mentioned above, the depth corresponding to an increase of 1° varies from 92.3 to 167 feet.

Conclusive as are the experiments in mines with regard to the increase of temperature, they after all refer only to comparatively slight depths. The depths at which observations have been made in artesian wells exceed those of the mine experiments. As is well known, by means of these artesian wells, a vent is opened whereby the water of subterranean reservoirs or springs, confined at great depths, finds a passage to the surface. This water, having found its way from the surface into those depths, is generally subject to a very strong hydrostatic pressure, and possesses the temperature of the depth from which it is liberated. The bore-holes, by means of which these subterranean reservoirs are tapped, are especially fitted for experiments as to the temperatures of various depths, since their depth, while being bored is accurately known, and since they are always filled with water. Such experiments have repeatedly been made, and have led to the complete and incontrovertible confirmation of the fact that the temperature of every constant depth, beneath the influences of the variations of temperature on the surface is invariable, and that the temperature increases continually with the depth. The following tables contain some of the most remarkable observations of this nature.

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[*] Reich: Beobachtungen über die Temperatur des Gesteines, 1834.

[†] Naumann; Lehrbuch der Geognosie, I, 54.

Artesian well at Rudersdorf, near Berlin :—

Depth.	Temperature.	
380 feet	17.12°	Centigrade.
500 "	17.75°	"
655 "	19.75°	"
880 "	23.50°	"

Artesian well of Grenelle, in Paris :—

Depth.	Temperature.	
917 feet	22.20°	Centigrade.
1231 "	23.75°	"
1555 "	26.43°	"
1684 "	27.70°	"

Artesian well of Neusalzwerk, Westphalia :—

Depth.	Temperature.	
580 feet	19.7°	Centigrade.
1285 "	27.5°	"
1935 "	31.4°	"
2144 "	33.6°	"

In the artesian well at Mondorff, in the Grand Duchy of Luxemburg, at a depth of 2066 feet, a temperature of 34° Centigrade was even observed. We have already seen that the results of the experiments in mines, as to the depth corresponding to one degree of increase, varied considerably. The results obtained in artesian wells as to this point were much more satisfactory. The distance corresponding to an increase of 1° was found to be:

At Rouen	90. 8	Feet.
At Mondorff	91. 1	"
At Rüdersdorf	92. 0	"
At Neusalzwerk	92.27	"
At Grenelle	95. 0	"
At St. Andre (Eure)	95. 3	"

These results shew a remarkable coincidence, but there are others which shew extraordinary differences, such as the following:—

At La Rochelle	60. 6	Feet.
At Pitzbuhl near Magdeburg	80. 0	"
At Artem in Thüringia	120. 0	"[*]

These latter results, as well as those differing widely from each other, which have been obtained in mines, are not to be regarded as at all invalidating the general result. These differences may be caused by variations in the conducting capacity of the various rocks; by the neighborhood of subterranean water courses; but especially by the greater or lesser distance of the point of observation from the source of the internal heat; in other words by the varying thickness of the earth's crust.

We have thus seen that actual observations have been made as to the temperature of the crust at various depths beneath the surface, sometimes as much as 2000 feet, and the result of these has been to prove that an increase of temperature takes place with the depth, amounting on the average to about 1 ° Cent. for every 100 feet. We have next to enquire as to whether any increase of temperature takes place at still greater depths. We have abundant proofs that this further increase does take place, in the temperatures of the thermal springs so widely distributed over every part of the surface of the globe. These temperatures are much higher than those which have been observed in mines or artesian wells. The waters of these springs rush with extraordinary force out of the ground, from which circumstance we may conclude that they ascend from their sources, with a rapidity which does not permit them to cool very considerably in their passage through the upper and colder strata. Although we are ignorant of the exact depth from which the waters of these springs rise, we are nevertheless justified in assuming that they come from greater depths than those of mines or artesian wells.

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[*] Naumann's Geognosie, I, 48.

The highest temperature yet observed in the latter was at Mundorff, viz,, 34 ° Centigrade. The following is a list of remarkable thermal springs whose temperatures exceed that just mentioned.

Spring.	Temperature.	
Pfäffers	37.2 °	Centigrade.
Wildbad	37.5 °	"
Barrèges	40.0 °	"
Aix-la-Chapelle	44 ° to 57.5 °	"
Bath	46.25 °	"
Leuck	50.2 °	"
Aix in Savoy	54.3 °	"
Ems	56.25. °	"
Baden-Baden	67.5 °	"
Wiesbaden	70.0 °	"
Carlsbad	75.0 °	"
Burtscheid	77.5 °	"
Katherine Spring in Caucasia	88.7 °	"
Trincheros in Venezuela	97.0 °*	"

We have here a series of temperatures, from the warmest yet observed in artesian wells to that of boiling water, and it would seem not unreasonable to suppose that the differences in their temperatures correspond to differences in the depths of their sources. It is true that the neighborhood of volcanoes or of igneous rocks may heighten the temperature of springs rising from comparatively shallow depths, but it is also the case that many very hot springs occur in districts far distant from volcanic regions. Thus it is with the hot spring of Hammam-mes-Kutin, betwixt Bone and Constantine, the temperature of which is stated at from 60 ° to 95 ° Cent.; and also with the warm springs in Cape Colony, which, according to Kraus, break forth from sandstone, far from any plutonic rock.† It is clearly impossible to account for the differences in the temperatures of thermal springs in any other way than by supposing that the springs possess very nearly the temperatures of the depths from which they rise, and that the higher the temperature of the water the deeper is the source from which it springs. We are therefore justified in regarding it as fully proved that the temerature of the earth increases with the depth, until a point is reached at which water boils. It is a matter of much difficulty however to determine, with any degree of precision, the depth at which this heat is attained. If we assume that the same increase of 1° Centigrade for every 100 feet depth, which takes place at the surface, continues to greater depths, the calculation is very simple. The temperature of the Mondorff artesian well was 34° Cent., at a depth of 2066 feet. If we add 100 feet for each of the remaining 66° C, we have a temperature of 100° C, at a depth of 8666 feet. It will however be shewn in a subsequent part of this paper, that we are not justified in assuming that the increase of temperature follows such a regular progression, that the rapidity with which the temperature increases, diminishes with the depth, and that consequently the depth at which a constant temperature of 100° C. reigns, is much more considerable than that above stated; that it is at least 10,000 feet, and probably even as much as 20,000 feet.* It is quite possible that under the great pressure which must exist at this latter depth the boiling point of water may be higher than 100° C., but then however, this might be it could not retain this higher temperature until it reached the surface. Because however rapidly it might ascend, its temperature would on the way decrease with the removal of the pressure, steam being at the same time generated. It is not improbable that the waters of the Geyser and the Strokkr have at their sources a much higher temperature than 100° C., and that the eruptions observable at these springs are caused by the generation of steam in the canal of egress, owing to the removal of the pressure. This view is supported by the observations made on the temperature of these springs. The water of the Geyser at the surface has a temperature of 76° to 89° C., but at a depth of twenty-two meters it is from 122° to 127° C. The water of the Strokkr is continually boiling at the surface, and has, at a depth of forty-one feet, a temperature of 114° C.† But although it is possible for water to exist at a much higher heat than 100° C, at such great depths, it is nevertheless also evident that at still greater depths, and increased temperatures, it can only exist in the form of steam. We can moreover readily conceive a depth and temperature to which it would be impossible for water to penetrate. If the temperature of the earth's crust continues to increase with the depth, there must exist at some depth, sufficiently great, a point beyond which the rocks are heated to such an extent that before water can penetrate to them it is resolved into steam and expelled.

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* Muller's Kosmische Physik, p. 340.

† Naumann's Geognosie, I, 306.

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* Naumann, Geognosie, I, 66.

† Krug von Nidda, in Karsten's Archiv für Mineralogie, &c., ix, 247.

Beyond this point there is a long interval, regarding the increase of temperature in which, we have no direct evidence until we arrive at that furnished by the fused rock which in the form of lava is poured forth by volcanoes, which are even more widely and generally distributed over the earth's surface than thermal springs. This however supplies indirect evidence sufficient to prove that during this great interval the heat must increase with the depth, until the temperature of fused lava is reached, at which point we must suppose everything to be in a fluid state, and consequently the temperature from that point to much greater depths to continue about the same. The lavas which have been emitted by volcanoes in historic times, have been both of a trachytic and a basaltic nature, but those of the latter character seem to have predominated. Many of these doleritic or augitic lavas from very recent lava-streams have been described and analysed. They are of a comparatively basic composition, seldom contain more than 50 per cent of silica, and are much richer than other volcanic rocks in iron-oxide. The lava which constituted the stream from Etna, that destroyed a great part of Catania in 1669, had the following composition:—

Silica	48.83	
Alumina	16.15	
Protoxide of iron	16.32	34.97
Protoxide of manganese	.54	
Lime	9.31	
Magnesia	4.58	
Soda with some potash	3.45	
Potash	77	
	99.95.*	

This analysis bears a general resemblance to those of other augitic lavas. It also bears a resemblance to that of the slag produced in smelting the copper schists of Mansfeldt. According to Hoffman, the composition of the slag produced at Kupfer Kammerhütte in the first or raw smelting, is as follows.

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* Bischof; Chemical and Physical Geology, ii, 235.

Silica	48.22	
Alumina	16.35	
Protoxide of iron	10.75	35.28
Lime	19.29	
Magnesia	3.23	
Protoxide of copper	75	
“ “ zinc	1.26	
	99.85.*	

According to Plattner, the melting point of these slags is about 1400° Centigrade.† If we suppose that the increase of temperature downward in the earth's crust progresses at the rate of 1° C. for every 100 feet, the thickness of the earth's crust may be calculated as follows. The temperature of the Mondorff artesian well was 34° C, at a depth of 2066 feet. If we add 100 feet for each of the remaining 1366° (136,600 ft.)—the temperature of 1400° would exist at a depth of 138,666 feet, (26¼ English, or 22¾ geographical miles.) However crude and uncertain this method of calculating the thickness of the earth's crust may be, it appears nevertheless to have been almost the only one hitherto employed for that purpose. It seems to have been assumed on all hands that the increase of temperature takes place in the ratio of a simple arithmetical progression. Humboldt‡ adopts the idea that “granite is in a state of fusion about “26 or 30 geographical miles beneath the surface.” At another place§ he states it at “somewhat more than 20 geographical “miles ($21\frac{6}{10}=25$ English).” “45,000 metres=24 geographical “miles, was named by Elie de Beaumont (Geologie, edited by “Vogt, 1846, I, 32) as the thickness of the solid crust of the “earth. Bischof (Warmelehre des Innnern unseres Erdkör-“pers, pp, 271 and 286,) estimated it between 122,590 feet and “136,448 feet, or on the average 21⅓ geographical=24½ English “miles.” The average diameter of the earth being 6864 miles, it follows from the above estimate, that the thickness of the earth's crust only amounts to about $\frac{1}{150}$th of the radius of its circumference. When we reflect on this result, it would appear that this thickness is altogether insufficient to lend to the earth's crust that stability which it now possesses. Moreover, there are other estimates than those above quoted, which give to the earth's

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[*] Kerl. Handbuch der Huttenknude, I, 296.

[†] Ibid; I, p. 282. [‡] Kosmos; English edition, I, 26. [§] Ibid V, 169.

crust a much more considerable thickness. Cordier assuming 100° Wedgewood as the melting point of lava, determined the depth at which everything is in a fluid state, from his observations:—

At Canneaux, to be 148 English geographical miles.
At Littry .... 84 ..... do.
At Decise .... 64 ..... do.

And he finally draws the conclusion that the average thickness of the solid crust of the earth cannot well exceed 56 English geographical miles.* Sartorius von Waltershausen's estimate will be referred to when we come to take into consideration the density of the earth. Naumann remarks as follows on the subject: "the temperature of the fused lava may certainly in the depths of the earth be estimated as at least 2000° C. If the increase of temperature follows the law of an arithmetical progression, then such a temperature would be reached at a depth of 200,000 feet, or nine German, (=36 English) geographical miles. But since it is more probable that the distance corresponding to an increase of 1° Centigrade augments with the depth, we are justified in assuming a much greater depth, and in supposing it not at all impossible that the seat of the fluid lava is to be found at a depth of twenty and perhaps even upwards of thirty geographical miles (=80 or 120 English geographical miles,)"† There are not wanting observations to prove that the temperature of the earth's crust increases less rapidly towards the interior. Thus from a comparison of several observations, Fox deduced the result that within the first 600 feet, the temperature increases more quickly than in the following 600 feet. Henwood obtained similar results within the first 950 feet, and Rogers found in Virginia a notable enlargment with the depth, of the space corresponding to 1° increase. In the artesian well at Grenelle the temperature observed at

700 feet depth was.............................. 20.00° C.
1555 " .... 26.43° C.

The thermometer in the cellar of the Paris observatory shews a constant temperature of 11.7° C. Calculating from this depth of 86 feet, the distance corresponding to one degree's increase of temperature within the first 677 feet is 81.6 feet; and within the next 792 feet, 123 feet; which figures plainly shew an increase with the depth of the distance corresponding to 1° C. Bischof's experiments on the cooling of large masses of melted basalt also furnish a very convincing proof that the increase of temperature takes place less rapidly at greater depths. 48 hours after casting a globe of melted basalt, having a diameter of 27¼ inches, he found it to possess the following temperatures :—

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* Naumann, Geognosie, I. 74.

† Naumann, Geognosie, I, 67.

In the centre	153.5°	R.
45 inches from do.	136.0°	"
6.75 " " "	124.9°	"
9. " "	109.8°[*]	"

These observations also shew with increasing depth a diminution of the rapidity with which the increase of temperature takes place. They by no means furnish us however with secure data upon which to found a calculation as to the thickness of the earth's crust. Like the careful experiments in the mines of Prussia and Saxony, "a general law with regard to the increase of tempera" ture cannot be deduced from them." They are useful in so far as they prove the inaccuracy of all estimates of the earth's thickness founded upon the arithmetical progression of the increase of temperature, and justify the supposition of Naumann, that the crust of the earth may have a thickness of upwards of 120 English geographical miles.

There is however yet another estimate of the thickness of the earth's crust, the consideration of which will lead us to refer to the various views entertained as to the constitution of the interior of the earth. This estimate is thus referred to by Naumann: " W. " Hopkins has adopted a peculiar method for the solution of " this problem. By very acute observation and reasoning on the " nutation of the earth's axis, and the precession of the equinoxes, " he finds that these two phenomena must come out with different " values according as the earth is solid throughout, or fluid " throughout, or solid externally and fluid internally; in which " latter case different thicknesses of the solid crust will produce " different results. It is certainly the case that in order to a cor" rect estimate, the values of two important elements are necessary, " which are as yet unknown, viz., the condensing action of pres" sure, and the expanding action of such high temperatures. " Nevertheless, Hopkins has attempted to answer the question ap-

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[*] Naumann, Geognosie, I, 63.

" proximately, and gained the result, that according to the known " values of the nutation and precession, the thickness of the solid " crust cannot be less than one fourth or one fifth of the radius " of the earth and must at least amount to 172 to 215 " German geographical miles (= 688 to 860 English geographical miles.) Such a thickness of the earth's crust seems indeed " to stand in the necessary relations to the stability of the exterior " surface of the earth, but also almost completely to exclude the " possibility of a communication with the interior of the earth, " which is really so decidedly shewn to exist by varied volcanic " phenomena. Hopkins also adopts the view that with such a " thick crust a direct communication is impossible between the " interior of the earth and the surface. In order therefore to " explain the phenomena of volcanoes, he supposes the existence " of very large cavities here and there within the solid crust, " which are filled with easily fusible materials, still in a liquid " state, and which resemble colossal bubbles, enclosing whole seas " of fused substance.* Elie de Beaumont and others, on the other hand, entertain the view that spaces were formed between the solid crust, and the fluid centre which, at least in earlier geological periods, caused partial depressions of the earth's crust, and which are still to be considered as the real laboratories of volcanic activity.

Somewhat allied to Hopkins's supposition is Bunsen's theory, which rests upon certain ascertained facts with regard to the composition of igneous rocks generally, but more especially to that of lavas. Bunsen supposes the existence in the interior of the earth of two enormous reservoirs of fused matter having each a different composition, and from the amalgamation of which all the known varieties of trachytic and doleritic rocks result. This theory is based upon two series of analyses of Icelandic lavas, the one comprising, according to Bunsen, those richest in silica (trachytes), the other those containing the largest amount of bases, (trap rocks, basalts and basaltic lavas). The first series of analysis comprised those of the following rocks :—

1. Trachyte from Baula.
2. Do from Kalmanstunga.
3. Do from Langarfjäll near the Geyser.
4. Trachyte from Arnar Knipa on the Laxa.
5. Do from Falklaklettur near Kalmanstunga.

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* Naumaun, Geognosie, I, 75.

6. Trachyte from Krabla.
7. Obsidian from Krabla.

	1.	2.	3.	4.	5.	6.	7.
Silica	75.91	77.92	75.29	78.95	76.42	76.38	75.77.
Alumina	11.49	12.01	12.94	10.22	9.57	11.53	10.29.
Ferrous oxide	2.13	1.32	2.60	2.91	5.10	3.59	3.85.
Lime	1.56	0.76	1.01	1.84	1.53	1.76	1.82.
Magnesia	0.76	0.13	0.03	0.14	0.20	0.40	0.25.
Soda	2.51	4.59	2.71	4.18	5.24	4.46	5 56.
Potash	5.64	3.27	5.42	1.76	1.94	1.88	2.46.
	100.00	100.00	100.00	100.00	100.00	100.00	100.00

The mean of these analyses is:

Silica	76.662	
Alumina	11.150	
Ferrous oxide	3.071	
Lime	1.469	23.338
Magnesia	0.274	
Soda	4.178	
Potash	3.196	
	100.00.	

This Bunsen assumes to be the composition of the normal trachytic mass, which occupies one of the reservoirs of his theory. The second series of analyses comprised those of the following rocks:

1. Trap rock from Esiaberg.
2. Trap from Vidoe.
3. Light fine grained basaltic rock from Hagafgëll on the right bank of the Thiorsa.
4. Basaltic rock from Skardsfjäll.
5. Lava from an old stream of Hecla.
6. Rock from the precipice of Almannagjö near the lake of Thingvalla.

	1.	2.	3.	4.	5.	6.
Silica	50.05	47.48	49.17	47.69	49.37	47.07.
Alumina	18.78	13.75	14.89	11.50	16.81	12.96.
Ferrous oxide	11.69	17.47	15.20	19.43	11.85	16.65.
Lime	11.66	11.34	11.67	12.25	13.01	11.27.
Magnesia	5.20	6.47	6.82	5 83	7.52	9.50.
Soda	2.24	2.89	0.58	2.82	1.24	1.97.
Potash	0.38	0.60	1.67	0.48	0.20	0.58.
	100.00	100.00	100.00	100.00	100.00	100.00.

The mean of these analyses is:

Silica	48.472	
Alumina	14.781	51.528
Ferrous oxide	15.383	
Lime	11.866	
Magnesia	6.890	
Soda	1.957	
Potash	0.651	
	100.000	

This Bunsen assumes to be the composition of the normal pyroxenic mass, which fills the second supposed reservoir of igneous fluid material in the centre of the earth. He further argues that all volcanic rocks, that is to say rocks belonging to the trachytic, basaltic or lava eruptive formations, may be regarded as mixtures of these two fluid materials, and shews that after merely determining how much silica they contain, it can be ascertained by calculation in what proportions these two materials from the different reservoirs are present. With regard to this theory Sartorius von Waltershausen remarks: "It is evident "that this average (that of the normal pyroxenic mass) can "just as little be regarded as the limit on the basic side, as the "so called normal trachytic average on the other. Nor is it "apparent why the above-mentioned six analyses only were used "in computing the average, while others, such as lava from Thiorsa, "and trap rock from Esia were neglected."*

Mr. Sterry Hunt, who as we shall see, rejects altogether the theory which derives the eruptive rocks from a portion of the primitive fused mass of the globe, and supposes them to consist of altered, fused, and displaced sediments, (Can. Naturalist, Dec. 1859], remarks, with regard to Bunsen's hypothesis, that the calculated results as deduced from the volcanic rocks of Hungary and Armenia, often differ considerably from those obtained by analysis; a result which will follow, when as is often the case, different triclinic feldspars replace each other in the pyroxenic rocks. He also shows that the composition of certain eruptive rocks, like phonolites, (which are highly basic, and yet contain but little lime, magnesia, or iron-oxide) is such that they cannot be derived from either of the magmas of Bunsen.

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* Ueber die vulcanische Gesteine in Sicilien und Island, und ihre submarine Umbildung; Göttingen, 1853.

Naumann quietly remarks that the theory of the two separate reservoirs is surely not yet sufficiently proved, and characterises Von Waltershausen's theory of the constitution of the interior of the earth as more natural, and more in accordance with our knowledge regarding the probable condition of the earth's centre.* This theory, which the author first promulgated in the work from which we have just quoted, deserves to be better known. It is principally founded upon certain reasonings deducible from the density of the earth, and for this reason a recapitulation of what is known concerning this point may not be inappropriate here.

In 1776 Hutton and Maskelyne determined the density of the earth from the attraction exerted on the plumb line by the mass of the mountain Schiehallion in Perthshire. Assuming the mean of specific gravities of the three principal rocks, of which it consists, viz., mica slate, limestones, and quartzite, to be the density of the whole mass, they calculated from their experiments the density of the earth to be 4.713.

The density of the earth has also been determined from observations on the oscillations of the pendulum on high mountains. In this way Carlini found from experiments on Mount Cenis the density of the earth to be equal to 4.37, which value was however raised by Schmidt to 4.837, by correcting an error in Carlini's calculations.

The most exact method however yet applied towards determining the density of the earth is that by means of the torsion balance invented by the Rev. John Mitchell, and used after his death by Cavendish. In 1798 this philosopher communicated to the Royal Society the result of his experiments with this apparatus. From seventeen sets of experiments he deduced twenty-three results, from the mean of which he computed the density of the earth to be equal to 5.48. Bailly, correcting an error in Cavendish's calculation, makes it 5.45. Schmidt, likewise, after a revision of Cavendish's computations, alters the result of these to 5.52. In 1837, Reich of Freiberg performed a series of experiments with the same apparatus, much improved in various particulars. Fifty-seven experiments were made in all, from which fourteen results were deduced, the mean of which makes the density of the earth equal to 5.44. In 1848 Baily, at the request of the Astronomical Society, undertook to repeat Cavendish's experiments.

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* Lehrbuch, ii, 1101.

It was not however until 1841 that the apparatus was modified and improved to such an extent as to give the most satisfactory results. The experiments with the perfected apparatus were continued till May, 1842, when the result was arrived at that the mean density of the earth is 5.66. From this enumeration of all the experiments which have been made for the determination of the mean density of the earth, it will be evident that the result as given by Baily, is one of the most unequivocally established scientific facts. Not only is there (considering, the different times and circumstances when they were instituted) a surprising coincidence in the results obtained by the torsion balance, but these are confirmed in the mean by the results obtained from the less accurate methods first described.

If we compare the mean density of the earth, as found by Baily, with the specific gravities of a few well known minerals, we find that it equals the density of copper glance, and exceeds that of magnetic iron ore, iron pyrites, variegated copper ore, and copper pyrites. If we moreover compare it with the specific gravities of these minerals or rocks which constitute the great bulk of the earth's crust, we find it to possess twice as great a density. The inference is unavoidable that the centre of the earth is much more dense than its crust, and is also possessed of a higher density than that of the earth's whole mass. This conclusion has, nevertheless, been received by many with grave doubts. It has even been supposed that the increased density at the earth's centre is attributable to the increased density which the substances there existing acquire from the enormous pressure of the superincumbent mass. This explanation rests upon the groundless supposition that solids may be compressed to an indefinite extent. It further neglects the very essential circumstance that the attraction exercised on any material point in the interior of the earth is only exerted by that part of the earth which lies within the spherical surface passing through the given point, and that the mass of the earth outside of this surface exercises no attracting influence on it. Since therefore the weight of a body is determined by the sum of the attracting forces acting on it, it follows that the weight of one and the same body must be less in the interior of the earth than on the surface.* Moreover, it is very certain that an extraordinarily high temperature exists in the interior of our planet, which must cause the bodies existing there to expand, and which must thus neutralise much of the compression exercised on these bodies by the masses lying above them. Finally, it seems that the compressing powers of the superincumbent masses have been somewhat over estimated. The crust of the earth must be regarded as a self-supporting arch, exercising a pressure only on the elastic fluids occurring in it, and not as resting or floating on the fluid interior. The latter has then only to bear the weight of the columns of lava which may exist in the interior of volcanoes, and which is certainly not inconsiderable. From these considerations it would seem perfectly correct to suppose that what the crust of the earth wants in density as compared with the whole mass of the planet, must be made up by the centre.

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* Naumann, Lehrbuch, i, 40.

Naumann finds that assuming the average density of the earth's crust to be 2·5, and the increase of density to take place according to arithmetical progression, the density of the centre would be 8·5, consequently considerably more than the specific gravity of iron, and almost equal to that of cobalt. A similar calculation is the starting point for the theory already mentioned of Sartorius Von Waltershausen. He finds the mean of the specific gravities of orthoclase, albite, quartz, crystalline limestone and mica to be 2·66, and assumes this as an approximation to the mean density of the outer crust. Calculating, first, three fifths of the total volume of the earth to possess this specific gravity, he finally computes the density of the centre to be 9·585. He moreover calculates the densities which exist at various depths beneath the earth's surface. These depths, converted into English geographical miles, with their calculated densities are as follows :—

Miles from surface.	Density.	
0	2·66	
34	2·79	
68	2·93	
103	3·07	Lime.
137	3·20	Magnesia.
171	3·34	
206	3·47	
240	3·60	
274	3.72	
309	3·85	
343	3·99	Alumina.
686	5·15	Iron-oxide.
1029	6·29	Tellurium, Chromium

Miles from surface.	Density.	
1372	7·09	Zinc, Iron, Antimony
1716	7.85	Cobalt, Steel.
2059	8·47	Uranium, Nickel.
2402	8·96	Copper.
2745	9·31	
3088	9·51	
3432	9·59	Bismuth, Silver.

The theory maintained by Sartorius Von Waltershausen regarding the constitution of the earth's interior, (in opposition to Bunsen's hypothesis of the two separate reservoirs of acid and basic molten rock,) is indicated by the above series of calculated densities. He supposes that from the interior of the earth's crust to its centre a gradual increase of density takes place in the fluid mass, or that this fluid mass in its present condition, as in former ages, consists of a series of concentric layers of molten matter, which are the denser the nearer they approach to the earth's centre. Instead therefore of regarding trachytic and basaltic lavas as the products of the two separate reservoirs, he considers them as the products of two different concentric layers, or as originating from two different levels in the fluid mass, the basaltic lava occupying the lower layer or level, and the trachytic floating above it; the one, both as regards chemical composition and density, graduating into the other. Von Waltershausen found the mean specific gravity of seven different Icelandic trachytes to be 2,524, while that of ten different basaltic lavas amounted to 2,911. With the increase of specific gravity towards the centre, Von Waltershausen supposes also an increase in the basic constituents of the molten rock, a change from a purely feldspathic material, yielding trachytic rocks mainly composed of feldspar, to one much richer in lime, magnesia and iron-oxide, and yielding dolerites consisting of feldspar, hornblende or augite, and in smaller quantity magnetic iron ore. He further supposes that beneath this doleritic material the quantity of iron-oxide, capable of producing the last named mineral, goes on increasing, and that ultimately a point is reached from which to the centre metallic elements alone exist. In further reasoning as to the condition of this metallic centre, Von Waltershausen takes into consideration the influence of the superincumbent pressure upon the fusing point of the metals. The following is a translation of his remarks on this subject: "For sometime past Bunsen has devoted his attention to this subject, and described (in Poggendorff's Annalen,

“ LXXXI, 562) a series of experiments from which it appears that the temperature of the fusing point of various substances increases with pressure. These experiments have it is true only been made on two easily fusible organic substances, spermaceti and paraffine. The melting point of the former is under a pressure of 100 atmospheres raised 2.1° Centigrade, while that of paraffine is raised 3.6° Centigrade. It cannot be doubted that a heavy pressure acts in a similar manner, although possibly not to such an appreciable extent, upon solidifying masses of silicates. If the point of fusion of the latter, under a pressure of 100 atmospheres, only increased 1° Centigrade, this would still be sufficient to explain many important points in geology, and especially in the formation of crystalline rocks. Although the law of the dependance of the point of fusion upon pressure is far from being known, the observations of Bunsen already mentioned have incited me to enquire as to what pressure, on the basis of the increase of density already mentioned, may be expected to exist at any given point in the interior of the earth. If we imagine the whole globe to be in a fluid condition, the following pressures would be experienced at the respective depths mentioned.

Depths in miles.	Pressure in atmospheres.
34	17138
68	34591
103	53070
137	72195
171	92432
206	113180
240	134660
274	156840
309	179680
343	203320
686	471680
1029	786080
1372	1125690
1716	1468000
2059	1701500
2402	2297500
3088	2441900
3432	2492600

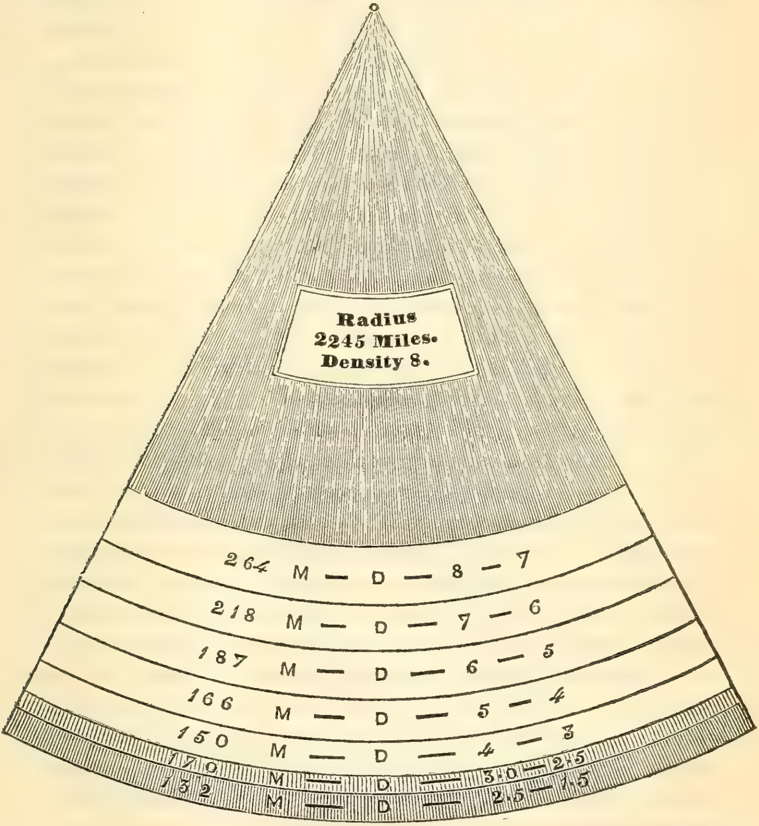
“If it is the case that the fusing point of metals (of which undoubtedly the greater part of our planet consists,) increases with increasing pressure, then the question arises as to whether under

" such enormous pressures as those above calculated, even with " the high temperatures which we have to expect in the interior " a fluid condition is conceivable. The hypothesis of a solid " metallic nucleus in the interior of the earth has nothing contradictory in it, and indeed the phenomena of terrestrial magnetism would appear to confirm this view. It is not to be " doubted that the so-called magnetic storms have their seat in " the atmosphere, or perhaps over it, and that the diurnal and " secular variations of the magnetic elements are only to be " sought in the exterior solid or solidifying crust of the earth. " If the seat of the greater part of the terrestrial magnetic " power is in the earth's crust, then we must suppose such a distribution of the magnetic fluid in it, as if on the average eight " hard steel bars weighing one pound each, magnetised to the " highest power, were present in every cubic metre. According " to geological observation, however, we can scarcely suppose the " seat of the magnetic power to rest in the earth's crust, since it " does not seem to possess either a very great thickness, or a " very intensive magnetism. According to an approximative calculation which my friend W. Weber has made, a globe of the " hardest steel, magnetised to the highest degree, and having a " diameter of nearly 476 (English) geographical miles, situated " in the centre of the earth, would be able to produce the magnetic phenomena which we observe on the earth's surface. In " reality however these suppositions are not reliable, since we can " neither expect to find hard steel nor a perfect magnetism in " the centre of the earth. With less favorable circumstances " than those above supposed, it would be necessary to assume the " existence of a much larger solid globe in the interior of the " earth in order to account for the magnetism on its surface. " The radius of this globe would possibly extend far beyond the " point at which, according to the calculations already mentioned, " a density equal to that of metallic iron exists."

In whatever degree Von Waltershausen's method of determining the earth's density at its centre, may be looked upon as uncertain, it is scarcely possible to regard his theory of the gradual increase of density as otherwise than very reasonable. Indeed since it is certain that the centre of the earth is much more dense than the surface, it is scarcely possible to conceive how the increase can take place otherwise than gradually. Moreover Laplace deduced a similar result from his investigations regarding the decrease of gravity from the pole to the equator. It appears however that Sartorius Von Waltershausen's estimate of the average specific gravity of the constituents of the earth's crust at its surface is too high, since it is well known that the land only occupies one-fourth of the earth's surface, and that the sea has sometimes a depth of more than 27,600 feet. It may probably be assumed with some degree of reason that the average specific gravity of the first few thousand feet of the earth's crust below the level of the sea, does not exceed 1.5. With regard to the metals constituting the earth's centre, it will probably be admitted that they exist there somewhat in the same proportion as they occur on the surface, that consequently iron constitutes by far the greater portion of the central mass. This supposition seems confirmed by the fact that among the gaseous products emitted by volcanoes, chloride of iron is very abundant, while traces only of the chloride of lead and copper have been detected. Since further, meteoric iron may be supposed to come from bodies having a common origin with our earth, their composition might be supposed to afford a clue, however slight, to the composition of the metallic centre of the earth. It would therefore seem not unreasonable to suppose that this centre is mainly composed of metallic iron, combined with copper, cobalt, nickel, lead, and perhaps silver, gold and platinum in comparatively small quantity, and that its specific gravity may be estimated on account of this admixture of heavier metals at 8. 0 (Sp. gr. of malleable iron 7. 78 ; cast iron, 7. 1 to 7. 5.) If we assume 1. 5 as the density of the earth's surface, and 8. 0 as that of its centre, we must also—since the average density of the earth is 5. 56—suppose the existence at the centre, of a globe of metallic matter having a radius of 2245 English geographical miles. Assuming further a gradual increase of density from the surface of the earth to the surface of this metallic globe, we may calculate that at a depth of 132 miles the density of trachytic lava is reached, (2. 5), and at 202 miles the density of doleritic lava is slightly exceeded (3. 0). According to this calculation therefore the crust of the earth has a thickness of from 132 to 202 miles, a result somewhat exceeding Naumann's estimate. Calculating in the same way we further find that from a depth of 202 miles to that of 352, molten rock would exist having a specific gravity of from 3. 0 to 4. 0, and containing much more basic matter and iron-oxide than any rock now visible on the surface. At a depth of from

352 to 518 miles, substances may exist having a density of from 4. 0 to 5. 0; such as magnetic iron ore, ilmenite, copper, iron, and magnetic pyrites, variegated copper ore, sulphuret of antimony, and perhaps antimonio-sulphurets. From 518 to 705 miles in depth, substances may be present having a specific gravity of from 5. 0 to 6. 0 such as iron pyrites, millerite, and copper glance. Deeper still, and until a depth of 923 miles, a density of from 6. 0 to 7. 0 may be supposed to exist, and consequently arsenio-sulphurets of iron, cobalt and nickel, such as arsenical pyrites and speiss-cobalt, cobalt glance, and tesseral pyrites to be present. Between this depth of 923 miles, and that of 1187 miles, where according to the calculation already mentioned, the surface of the metallic globe may be found, we may suppose a density of from 7. 0 to 8. 0 to exist, and more or less pure arseniurets, such as the purest speiss-cobalt, arseniurets of copper and nickel, &c, to be present. It will be evident that in calculating the results above given, I have only been endeavouring to develope Von Waltershausen's theory, and in some measure to correct his results. I say correct them, because in one instance assuming the sp. gr. of the surface as 2.66, he arrives at the result that the thickness of the earth's crust does not exceed 67 English geographical miles. So far as regards the composition of the various concentric layers deduced from their specific gravities, I may remark that I have observed a similar succession to that above indicated, manifest itself in smelting cobalt ores. This operation is carried on at Modum in Norway, where on drawing the metal from the furnace there are formed in the crucible receiving it, four different layers of material, which from the surface downwards, are as follows, viz.: Slag, containing about 60 per cent. of lime and oxide of iron; 2nd, sulphurets of copper, iron and cobalt; 3rd, Arseniosulphurets of iron and cobalt, graduating into 4th, impure metallic iron, malleable and containing cobalt. The accompanying sketch shows part of a section of the earth, exhibiting the size of the central metallic globe, the thickness of the concentric layers, and of the solid crust according to the above calculations. As to whether the metallic globe in the centre is in a solid state, there would appear to be good grounds for this supposition, because apart from the consideration that the solidifying point rises with the pressure, it is well known that in many smelting furnaces, metallic iron can accumulate in the bottom, while the slag maintains its fluidity and runs perfectly free from the furnace. Mr. Sterry

Hunt inclines also to the supposition that the centre of the earth is solid, although he is of opinion that the fluid matter resting above it is altogether of sedimentary origin, and is in a state of igneo-aqueous fusion. He remarks "that beneath the outer crust of sediments, and surrounding the solid nucleus, we may suppose a zone of plastic sedimentary material adequate to explain all the phenomena hitherto ascribed to a fluid nucleus." (American Journal of Science for May, 1861.) If, further, iron when fused loses its magnetic power, and the phenomena of magnism on the surface of the earth can be explained on the supposition that the metallic centre has assumed the solid form, then this supposition would appear to be very reasonable indeed. It would of course be impossible to assume that the metals have not only



solidified but also cooled to such an extent as to be capable of being magnetised to the most powerful degree. On the contrary, we must suppose them to be still very considerably heated, and consequently to possess but feeble magnetic properties. According to Humboldt, "all magnetism is certainly not lost until we "arrive at a white heat, and it is manifested when iron is at a "dark red heat." * The feeble magnetic power of the metallic globe would however be amply compensated for by its enormous size.

The possibility of the existence of such a metallic centre having been once admitted, the field opened for further reasoning as to the influence which cosmical bodies may exert upon its position, and consequently upon that of the earth's centre of gravity, is very wide indeed. That these changes may affect the phenomena of volcanic eruptions, I shall endeavour to shew in Part II. of this paper. In the meantime it may be remarked that there exists a decided connection between magnetic, and volcanic phenomena. In the year 1767, Bernouilli observed that during an earthquake the inclination decreased half a degree, and Father de la Torre remarked that during an eruption of Vesuvius the declination varied several degrees. On the 18th April, 1842, at ten minutes past nine, Kreil in Prague observed that the needle received a very sudden stroke, and the same oscillation in the same direction was observed at the same instant by Cella in Parma, and Lamont in Munich. Shortly afterwards it was ascertained that exactly at the same minute a violent earthquake had been felt in Greece.† From the irregularities in the course of the magnetic curves, Lamont regards it as in the highest degree probable that the seat of terrestrial magnetism is to be sought in a compact nucleus which lies under the earth's crust. Müller is of opinion that the magnetic variations and oscillations can be most simply explained by considering terrestrial magnetism as dependent on electric currents which pass through the nucleus in ever varying direction and intensity.‡

That the magnetic variations stand in connection with the movements of certain of the heavenly bodies is a well ascertained fact. Sabine came to the conclusion that the disturbances belong

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* Humboldt's Cosmos, English Edition, I, 183.

† Müller's Kosmische Physik, p. 497.

‡ Ibid, p. 498.

"to a special kind of periodically recurring variations, which "follow recognizable laws, depend upon the position of the sun "in the ecliptic, and upon the daily rotation of the earth round "its axis, and further ought no longer to be designated as irregular, since we may distinguish in them, in addition to a special "local type, processes which affect the whole earth."* The hypothesis of a metallic centre would seem to be capable of forming the connecting link between the magnetic and astronomical phenomena here referred to. The relation of the sun to the earth, and the revolution of the latter on its axis, would naturally effect a change in the position of the metallic globe in the centre of the earth, which change might alter the direction of the electric currents through the earth's crust, and these again the position of the needle. Thus it seems not at all unreasonable to adopt the theory of a metallic centre, since it alone is capable of affording a solution of many problems in geology, magnetism and astronomy, and since it is capable of uniting harmoniously and explaining the most varied natural pnenomena.

Art. XXIII.—*On the Earth's Climate in Paleozoic Times;* by T. Sterry Hunt, M.A., F.R.S.

The late researches of Tyndall on the relation of gases and vapors to radiant heat are important in their bearing upon the temperature of the earth's surface in former geological periods. He has shown that heat, from whatever source, passes through hydrogen, oxygen and nitrogen gases, or through dry air, with nearly the same facility as through a vacuum. These gases are thus to radiant heat what rock-salt is among solids. Glass and some other solid substances, which are readily permeable to light and to solar heat, offer, as is well known, great obstacles to the passage of radiant heat from non-luminous bodies; and Tyndall has recently shown that many colorless vapors and gases have a similar effect, intercepting the heat from such sources, by which they become warmed, and in their turn radiate heat. Thus while for a vacuum the absorption of heat from a body at 212° F. is represented by 0, and that for dry air is 1, the absorption by an atmosphere of carbonic acid gas equals 90, by marsh gas 403, by olefiant gas 970, and by ammonia 1195. The diffusion of olefiant gas of one inch tension in a vacuum produces an absorption of 90, and the same amount of carbonic acid gas, an absorption of 5·6. The small quantities of ozone present in electrolytic oxygen were found to raise its absorptive power from 1 to 85, and even to 136; and the watery vapor present in the air at ordinary temperatures in like manner produces an absorption of heat represented by 70 or 80. Air saturated with moisture at the ordinary temperature absorbs more than five hundredths of the heat radiated from a metallic vessel filled with boiling water, and Tyndall calculates that of the heat radiated from the earth's surface warmed by the sun's rays, one tenth is intercepted by the aqueous vapor within ten feet of the surface. Hence the powerful influence of moist air upon the climate of the globe. Like a covering of glass, it allows the sun's rays to reach the earth, but prevents to a great extent the loss by radiation of the heat thus communicated.

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* Humboldts, Cosmos, v, 138.

When however the supply of heat from the sun is interrupted during long nights, the radiation which goes on into space causes the precipitation of a great part of the watery vapor from the air, and the earth, thus deprived of this protecting shield, becomes more and more rapidly cooled. If now we could suppose the atmosphere to be mingled with some permanent gas, which should posses an absorptive power like that of the vapor of water, this cooling process would be in a great measure arrested, and an effect would be produced similar to that of a screen of glass; which keeps up the temperature beneath it, directly, by preventing the escape of radiant heat, and indirectly by hindering the condensation of the aqueous vapor in the air confined beneath.

Now we have only to bear in mind that there are the best of reasons for believing that during the earlier geological periods, all of the carbon since deposited in the forms of limestone and of mineral coal existed in the atmosphere in the state of carbonic acid, and we see at once an agency which must have aided greatly to produce the elevated temperature that prevailed at the earth's surface in former geological periods. Without doubt the great extent of sea, and the absence or rarity of high mountains, contributed much towards the mild climate of the carboniferous age, for example, when a vegetation as luxuriant as that now found in the tropics flourished within the frigid zones; but to these causes must be added the influence of the whole of the carbon which was afterwards condensed in the form of coal and carbonate of lime, and which then existed in the condition of a transparent and permanent gas, mingled with the atmosphere, surrounding the earth, and protecting it like a dome of glass. To this effect of carbonic acid it is possible that other gases may have contributed. The ozone, which is mingled with the oxygen set free from growing plants, and the marsh gas, which is now evolved from decomposing vegetation under conditions similar to those then presented by the coal fields, may, by their great absorptive power, have very well aided to maintain at the earth's surface that high temperature the cause of which has been one of the enigmas of geology.

Montreal, August 1st, 1863.

MISCELLANEOUS.

THE CONFUSED MONOHAMMUS!

To the Editor of the Canadian Naturalist.

The longicorn described by me (Canadian Journal, 1st series, vol. iii, p. 212) as *Monohammus titillator*, Fab., was determined by Mr. Ibbetson and myself from the best American Entomological authority that could be obtained at the time.

Mr. Billings states (Canadian Naturalist, vol. vii. p. 431), that " *M. confusor* is the largest insect." I disagree with him, because the longicorn family, and this genus especially, has its species of maximum and minimum lengths and breadths, a fact that cannot be overlooked by a person collecting a number of each species. He further says: " As neither Mr. Ibbetson nor myself mention *M. confusor*, and as the original specimen on which the species *M. titillator* was founded is an insect from the Southern States, it may be that they have applied the name to our most common and largest species."

Fabricius may have procured his specimen from the South, probably from the southern limit of pines; but since his time American Entomological authority formed a boundary, north of which our insect provinces are formed into zones; through these we may follow the species to the extreme north. Insects therefore, taken north of Mexico are considered as belonging to the northern fauna; indeed, many forms mentioned by Linnæus and Fabricius as having a southern habitat, are found commonly in the north. What then is to prevent the appearance of *M. titillator* in Western

Canada when it occurs in NewYork and Pennsylvania? The former place is in closer proximity to the land of pines and the climate congenial to its propagation.

In a letter to the Editor of the "Canadian Naturalist" (quoted below), "H. C.", confirms this idea of Mr. Billings, and at the same time states that the drawing of *Monohammus titillator* in Olivier's work (an excellent authority) agrees very well with these specimens.

Is *M. titillator* a species, and what difference is there between it and *M. confusor?* "H. C." remarks that "in a recent edition of Harris' work the name is still employed", therefore doubting its specific existence. The principal coleopterists of the United States consider it a species. (See Proceed. Ento. Soc. Philad. p. 98), and I quote the following from the Patent Office Report: Agriculture—Washington U. S., 1861, p. 613. by S. S. Rathoon: "One of the largest species of Capricorn beetles belonging to this group is the *Monohammus titillator*, or "tickling beetle." This insect is from three quarters to an inch and a quarter in length, and the antennæ of some of the males are considerably more than twice the length of the body, bristle-shaped, and tapering gradually to the end. The head is vertical in these insects, carried very much like the head of a gnat; the eyes are oval and located immediately beneath the base of the antennæ; the thorax is round in front and behind, but the middle projects out on each side in a sort of wart or rough tooth. The anterior legs are rather the longest, and the tarsal joints much dilated. The colour of the whole insect is a brown mottled with specks of gray or white. On the upper edge of the middle legs is a small obtuse tooth, but in some individuals this is hardly visible. This insect emerges from the pupa state during the months of June and July. Mr. P. Uhler, of Baltimore writes to Mr. Rathoon: "I guess you are right in supposing the larva of *Monohammus titillator* (Harris), to be brought down the Susquehanna in pine logs. It is found in pines in NewYork, from whence the river flows. The larva is a large white flesh-like grub, nearly cylindrical, without feet, numerous fine hairs of a fox colour, with fourteen segments, the second being larger, flattened, horny, inclined obliquely downward and forward; the next ones very short, and all the following except the last one with a transverse oval rough space above and beneath. The pupa state is passed in the interior of wood, into which the larva bores a cylindrical hole transversely, and which, when the perfect insect gnaws its way out, is nearly large enough to admit the little finger. It appears abundantly in some parts of New-York state in July, sometimes doing extensive damage to the pine trees."*

Mr. Billings notices "in the collection of McGill College three specimens from Toronto of the size of the smaller individuals of *M. confusor*, which have a light reddish tinge different from the usual colour of that species." If the specimens alluded to are in the "Couper Collection" of that institution, the cases containing the insects are covered with glass; and the specimens having been exposed for several years to the light, it is no wonder that they have a tinge different from the usual color.

"H. C." says:—"The description agrees very closely with the reddish brown specimens mentioned by Mr. Billings as having been obtained from Toronto, where from my own observations they seem to be much more common than those of a cinereous tint."

Which description does "H. C." allude to—that of *M. titillator* or *M. confusor?* If my memory serves me,—for I have neither my description nor a specimen of the insect, the longicorn pointed out by Mr. Ibbetson and myself as *titillator*, was a large brown or cinereous beetle, with its elytra mottled by tufts of erect short hairs of a blackish grey colour. I cannot say that the collection which I sold to McGill College contained a specimen of *M. titillator*, but I am positive that Mr. Ibbetson, an excellent coleopterist, identified the form prior to his removal from Toronto to Montreal.

Wm. Couper,
Quebec, L. C.

To the Editor of the Canadian Naturalist.

In the December number of the *Canadian Naturalist*, Mr. Billings has described some of the pine-boring beetles of Canada, of the genus *Monohammus*, and mentions that the *M. titillator* is cited by Mr. Couper and Mr. Ibbetson as occurring at Toronto, but is of opinion that the insect described is the *M. confusor*.

I can confirm this idea of Mr. Billings, as the insects in my own collection and in that of Mr. Ibbetson were named on reference to Harris' work. The description agrees very closely with the reddish brown specimens mentioned by Mr. Billings as having been obtained from Toronto, where from my own observations they seem to be much more common than those of a cinereous-tint.

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* Mr. Rathoon's fig. of *M. titillator* (Pat. Office Rep.—Agricul. 1861) has 13 antennal joints.

Moreover the drawing of *Monohammus titillator* in Olivier's work agrees very well with these specimens. Those in my collection are mostly of the same size as the *M. confusor* and generally a little more robust, but are probably only a variety. The *M. scutillatus* is moderately common about Toronto, but the *M. marmoratus* quite rare; the latter easily distinguished by its smaller size, its rugosely punctured thorax, and the elytra mottled with brown and grey.

In my collection there is also a crippled specimen very like *M. scutillatus* but the elytra are covered with large white spots, in this respect resembling Leconte's *M. fatuor*, which however is now referred to *M. marmoratus.*

In the recent edition of Harris' work the name *titillator* is still employed. H. C.

"Notice of a new Species of *Dendrerpeton*, and of the Dermal Coverings of certain Carboniferous Reptiles." By J. W. Dawson, LL.D., F.R.S., F.G.S.

This paper referred to new facts ascertained in the course of re-examination of the remains of Reptiles from the Coal-formation of Nova-Scotia, and first to the characters of a new and smaller species of *Dendrerpeton*, for which Dr. Dawson proposed the name of *D. Oweni.* The author then described the remains of skin and horny scales which he had lately discovered, and which he supposed to belong to *Dendrerpeton Oweni*, *Hylonomus Wymani*, and *H. Lyelli.* He also gave restorations of these animals, according to what he regarded as the more probable arrangement of the parts; and, after expressing his belief that *Hylonomus* may have Lacertian affinities, he stated that should they prove to be really Batrachian, a new Order must be created for their reception, many of the characters of which would coincide with those of the humbler tribes of Lizards.—*Journal of Geo. Society.*

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ART. XXIV—*On the Origin of Eruptive and Primary Rocks;* by THOMAS MACFARLANE. *Part II.*

(Presented to the Natural History Society.)

II. THE ERUPTIVE FORMATIONS.

In referring to these formations, it will be impossible altogether to avoid mentioning many matters, which are very generally known regarding them. Still the connection of eruptive rocks on the one hand with the constitution of the interior of the earth as adverted to in the last chapter, and on the other hand with certain slaty modifications of themselves, will be kept in view as much as possible. The rocks of these eruptive formations possess, as is well known, characters which distinguish them sharply from rocks of sedimentary origin. While the latter have been made up of the debris of rocks pre-existing on the earth's surface, the eruptive formations have derived their material from beneath the earth's crust. Hence they have been respectively termed by Humboldt exogenous and endogenous rocks. The eruptive rocks are more or less crystalline, generally but not always unstratified. The sedimentary rocks possess opposite characters. Each eruptive rock is in a high degree homogeneous and shows nearly the same characters and composition throughout its whole mass. This is much less the case with sedimentary rocks. The eruptive rocks occur in very irregular forms, as enormous irregular masses, (typhonische stöcke) covers or caps (Kuppen or Decken), veins, streams and layers. Sedimentary rocks occur only in the latter form. Eruptive rocks are totally destitute of fossils and their ages are determined by the relations of contact, which exist between them and sedimentary rocks. Fossils constantly occur in the latter, and constitute the principal means of determining their age. Eruptive rocks resemble in the mode of their formation the slags, which run out of smelting furnaces; sedimentary rocks the slimes deposited in stampworks and allowed to consolidate.

The eruptive formations have been arranged in the order of their antiquity by Naumann as follows:

1. The granulite formation.
2. The granite do.
3. The syenite do.
4. The greenstone do.
5. The porphyry do.
6. The melaphyr do.
7. The trachyte do.
8. The basaltic do.
9. The lava do.

This arrangement is however general and approximative. Not only do the rocks of these formations in their lithological character graduate into each other, but the latter part of one formation may have been erupted simultaneously with the earlier rocks of the succeeding one. Thus trachytes and basalts are almost of contemporaneous origin, and porphyries have been protruded through the earth's crust in the same periods as certain greenstones and melaphyrs. I shall therefore class several of these formations together and refer to them in the following order:

1. Trachyte, Basalt, and Lava. The volcanic formations of Naumann.

2. Phorphyry, greenstone and melaphyr,	The plutonic formations of Naumann.
3. Granite, syenite, and granulite,	

Trachyte, Basalt, and Lava. I have already adverted to the distribution of volcanoes as constituting a proof of the existence of a molten zone betwixt the central metallic globe and the crust of the earth. I do not deem it necessary to enlarge much upon this point. As Naumann remarks: "Volcanoes exist in every part of the earth, under every latitude, under the equator and near to the poles, in the torrid as well as in the temperate and frigid zones. They are confined to no climate, because in Iceland, Kamschatka and the Aleutian Island, between a latitude of 50° and 66° they exist as numerously as in the Sunda isles, Galapagos and in Quito between 0° and 10° lat. But we find them especially frequent on the coasts of continents or rising out of the depth of the ocean, proving that there the conditions are especially present which are necessary to their development and activity. From all this we may conclude that the material cause of Vulcanism is present everywhere beneath the earth's crust, although it may only have been able to break out along certain lines and at certain points." By means of volcanoes and the subterranean canals connected with them, a communication is established between the molten zone beneath the earth's crust and the atmosphere. This communication is liable to be interrupted by various circumstances, and when this is permanently the case the volcano is extinct. But even the active volcanoes are far from being continually in a condition of violent eruption, their usual activity is rather of a very temperate character, and F. Hoffmann very correctly remarks that the energetic eruptions are more the exception than the rule. Volcanoes in a state of rest exhale steam and other gases and it is even the case, that a quiet effusion of lava can take place unaccompanied by any extraordinary phenomena. Generally however the ascent of the lava in the canal and crater of the volcano is the immediate cause of all the sublime effects and terrible devastations, which accompany and follow volcanic eruptions. It is still a matter of doubt among philosophers as to what is the real cause of the ascent of the lava from its home in the depths of the earth. The oldest hypothesis is that which attributes the force, which expels the lava to highly compressed steam, resulting from the access of water, and especially of sea water, to the regions filled with igneous fluid beneath the earth's crust. In later times this view has been adopted by very many philosophers such as Gay Lussac, Von Buch, Angelot, Bischof, and Petzholdt. On the other hand, Humboldt does not at all regard the problem as completely solved,* and Naumann does not consider it probable that the expansive force of the steam derived from sea-water is the cause of the ascent of the lava, although he considers it as quite certain, that sea and other water obtains access through the eruptive canals of volcanoes to very great depths, and on the ascent of the lava plays a very important part in the phenomena of volcanic eruptions. Naumann's view so far as regards the part played by water seems very reasonable. We can readily conceive that it would be difficult for water, even under considerable pressure, to obtain access by means of fissures or otherwise through the solid crust of the earth to the smelted mass beneath. As previously remarked, it would be impossible for it to penetrate the highly heated rocks constituting the inner part of the earth's crust. But it would seem very possible, especially in those volcanoes situated on the coasts of continents, for water to obtain access to great depths in the craters and subterranean canals. As to the cause of the rise of lava in these, Naumann propounds the following theory:

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* Cosmus I, 243.

"The solidified crust encloses the fluid interior of our planet, and at their junction the same solidifying process, by which the crust of the earth was formed, must still be going on. Because however imperceptible the radiation of the internal heat may now be, it still continually takes place although in a lesser degree; and it cannot be doubted that on the inner side of the earth's crust fluid matter is continually assuming the solid form. It is indeed the case that the greatest number of fluid bodies experience a diminution of their volume, and only a few of them, such as water and bismuth, expand, while solidifying, but we must reflect that the relations as to density of the bodies existing in the great depths of the earth where vulcanism has its seat, must be essentially different from those, which they possess on the surface, where we can experiment with them. The pressure of the superincumbent masses must compress the materials existing at these depths. But fluid bodies are gifted with a much greater degree of compressibility than solid bodies, and therefore it can easily happen, that the most and perhaps all fused material which solidifies on the inside of the earth's crust experiences in this solidification an increase in its volume. The unavoidable consequence of this can be no other than that during this slowly progressing solidification a diminution of the capacity of the earth's crust takes place, that consequently the the space enclosed by it and filled with fused material is contracted. The next consequence will be, that a part of the fluid material will be pressed up sometimes through one and sometimes through another volcanic canal, until the weight of the column of lava equalizes the pressure in the interior. In this way the first conditions are given by means of which volcanic eruptions become possible."* The objections to this theory lie in the following considerations. The difference in the compressibility of fluid and solid bodies does not seem to be very considerable. Water is but slightly compressible. According to Oerstedt, the compression produced by a pressure of 2000 atmospheres amounts only to 1-12th.,* and one would suppose that fluid lava would be even less compressible than water. The decrease of compressibility which may accompany solidification would therefore seem inadequate to the production of such stupenduous effects as are observable during volcanic eruptions. Further, if this were the cause of the ejection of the lava, the latter would be poured forth only by volcanoes of inconsiderable height, but by these simultaneously. Its ejection would also keep pace with the very slow and gradual solidification in the interior, and violent volcanic paroxysms would not occur.

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* Lehrbuch I. 289.

Sartorius Von Waltershausen likewise assumes, that expansion takes place, but he does not attribute it to the mere difference in the compressibility of the igneous material before and after solidification. He supposes that the expansion takes place in the act of crystallization i, e. while the various minerals form and separate themselves from the fluid magma.† He fails however to adduce any conclusive evidence in support of this supposition, which it might be possible to sustain, in the event of its being possible to show that melted rock rapidly cooled to a fine grained crystalline mass, had a lesser specific gravity than the same slowly cooled and distinctly crystallized. He indeed shows that the specific gravities of the minerals which result in the cooling of igneous rocks, are invariably less than those which result in calculating their specific gravities from the quantities and densities of their constituents; as the following instances show :—

Substance.	Density.	
	by experiment.	from calculation.
1. Anorthite from Selsfjäll	2. 7	3.225
2. Labradorite from Egersund	2.705	3.212
3. Orthoclase from Baveno	2.555	2.935
4. Augite from Monte Rosso	2.886	3.208
5. Hornblende from Ætna	2.893	3.447
6. English crownglass	2.487	2.721
7. Guinands Flintglass	3.77	5.64
8. Bohemian glass	2.396	2.735

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* Gmelin, Hand-book of Chemistry, II. 62.

† Uber die vulcanishen Gesteine, etc., p. 333.

But this does not prove that a fused silicate, the constituents of which are already in chemical combination with each other, experiences a dimunition of density or increase of volume in cooling and crystallizing. The only instance of the cooling of a fused silicate, which has been made the subject of observation so far as regards density is the formation of Reaumur's porcelain from glass, but this goes rather to prove the opposite of Von Waltershausen's theory. Many kinds of glass, after exposure for several hours to a heat at which they become soft, pass into a condition resembling porcelain, become opaque, doubtless from the separation of fine particles, whose composition differs from the mass. The resulting "Reaumur's porcelain" is specifically heavier than the glass from which it is prepared. Moreover, this substance when again fused and *rapidly* cooled yields an enamel the specific gravity of which is to that of the substance before fusion as 2,625 is to 2,801.[*] From this it would appear that instead of an increase a diminution of volume takes places in the slow cooling or crystallization of fused silicates.

If we reject both the hypotheses just mentioned, the only explanation left, whereby the ascent of the lava column may be accounted for is that which is regarded as the cause of the more widespread earthquakes, viz. the fluctuations of the surface of the fluid interior of the earth.[†] While those earthquakes which occur simultaneously with volcanic eruptions and in volcanic districts may be considered as a consequence of the lava rising in the volcano, the same can scarcely be said of those earthquakes which occur in the midst of continents far distant from any volcanic region. According to Naumann, the most probable cause of these "plutonic" earthquakes is "a fluctuation of the surface of the "fluid kernel of the earth commencing from a line or a point, "and progressing according to the laws of the motion of waves." The cause of such fluctuations he leaves undecided, but in commenting upon von Hoff's, Merian's and Perrey's investigations as to the greater frequency of earthquakes in certain seasons of the year he propounds a question, the consideration of which would seem to yield the most important results. The investigations referred to established the fact that in the northern hemesphers in winter earthquakes are of greater freuency than during any other seasons. Von Hoff found that of the 115 earthquakes which, during the 10 years from 1821 to 1830, had been experienced in that part of Europe lying north of the Alps, 21 had occurred in summer, 34 in autumn, 43 in winter, and 17 in spring. In the same way Merian arranged all the earthquakes, which had been observed in Basle up to the end of 1836, with the following results:

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[*] Gmelin III, 385.

[†] Naumann: Lehrbuch, I, 291.

Summer 18.
Autumn 39.
Winter 41.
Spring 22.

The most important statistics of this character have however been furnished by Perrey of Dijon, who seems to have given special consideration to this subject. He has classified, according to the seasons of the year, 2,979 earthquakes, which have taken place in Europe and the immediately adjoining parts of Africa and Asia from the year 306 to the year 1844, and found:

653 to have taken place in summer
705 " autumn
911 " winter
710 " spring

The maximum falls in the coldest and the minimum in the warmest season of the year, while in spring and autumn the numbers are almost equal. Naumann considers that these observations almost conclusively prove that "at least in Europe and the countries immediately bordering on it, autumn and winter must be regarded as the seasons, in which earthquakes most frequently occur." He adds that it is difficult to find a satisfactory explanation of this fact, that the cause ought perhaps to be sought for more in cosmical than in meteorological relations, and finally asks "*May not the position of the earth in the winter, i e. in the perihelion exercise an influence?*"* This question he leaves unanswered contenting himself with declaring that the mere difference of temperature in the seasons of the year can not explain the matter. If, as is supposed in the first part of this paper, there exists in the interior of the crust a central metallic globe surrounded by a fluid zone, it is quite reasonable to suppose that the former may be influenced by the heavenly bodies, that it is attracted by the sun and moon and that the attraction exerted is the more powerful the nearer these bodies approach the earth. Since the sun is nearest to the earth in the winter, there would appear to be grounds for attributing earthquakes partly to the attraction exercised by the sun upon the fluid interior, and the consequent pressure excercised by the latter on the earth's crust. It moreover appears from investigations made by Perrey subseqnent to those above mentioned, that the moon also exercises an influence.*

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* Lehrbuch, I, 213.

Quenstedt† thus refers to the latter investigations: "A. Perrey "has found from 7000 observations during the first half of the "present century that earthquakes are much more frequent in the "conjunction and opposition of the moon than at other times; "more frequent, when the moon is near the earth than when it is "distant, more frequent in the hour of its passage through the "meridian than at any other. From this it would appear, that "the moon is not without influence; that it occasions tides in the "central lava in the same manner as in the ocean, which tides "press against the earth's crust and seek an outlet." The latter part of this quotation seems to contain the explanation least liable to objection, of the rise of the lava in volcanoes. Not only may plutonic and volcanic earthquakes be attributed to this cause, but volcanic eruptions also, and with equal justice. If we adopt this explanation it is easier to comprehend why the lava should press forth at one in preference to another volcano, or burst open the obstructed canals of extinct volcanoes rather than seek an outlet through the vents already existing in the earth's crust.

Having thus discussed the various explanations of the cause of the rise of the lava in volcanic canals, the phenomena which attend volcanic eruptions may next be adverted to, with the view of ascertaining the origin of certain volcanic products. The lava gradually ascending from the depths of the earth, comes in the upper part of the canal and in the crater into contact and conflict with the water, which has found its way down from the surface, and which may have collected in subterranean reservoirs, or merely saturated the side walls of the vent. The water is by the heat of the lava resolved into steam, which then forces its way through the fluid to the surface, when the bubbles containing it explode. A similar phenomenon may be observed on a small scale at blast furnaces, when the slag runs out of the breast and over a place upon which water had been previously thrown. The slag boils up until it cools, and becomes too stiff to allow of the passage of the steam. This production and escape of steam in the craters of volcanoes takes place with a violence and intensity of which few but eye witnesses can form any idea. Sartorius Von Waltershausen thus describes a volcanic eruption principally in relation to the various products formed by it: "During an eruption the melted matter ascends from the deeper lying regions of the earth into the volcano where it serves both for the formation of volcanic ash and of lava. Steam prodigiously compressed tries, where it can, to break through the column of lava to the atmosphere. This escape of steam is the principal cause of that subterranean noise known as volcanic thunder. A continual struggle takes place between the elastic fluid, the fused mass and the solid walls of the volcanic canal, which struggle lasts so long as the development of steam in the latter continues. During this violent ascent of the enormous steam bubbles, which burst on reaching the surface of the lava reservoir, pieces of lava already cooled or still fluid are violently torn off from the latter and thrown high up in the air out of the crater. When the eruption is at its height, millions of these pieces, mostly red hot, from the size of mere miscroscopic particles to those with a diameter of one or more yards, fill the air above the crater, rising in myriads with each explosion, and falling again in perpetually changing motion. When the intervals between each explosion are short, as is the case with all violent eruptions, it frequently happens, that during a lapse of about 20 seconds, which time the glowing stones frequently take to complete their passage through the air, six to ten new explosions take place. It is evident that an uninterrupted volley and shower of stones mixed with the dense smoke of finer particles will thus be sustained, and this it is, which, partly glowing itself, and partly lighted up by the glow of the melted lava, in the crater, resembles a permanent flame. The fragments of lava thus thrown out of the crater differ from each other in size, in external form, (which is frequently determined by the temperature at which they were formed,) and in chemical composition. Blocks have been observed measuring 4 to 5 metres each way, smaller ones about the size of a cubic yard occur frequently, while from this size there are innumerable gradations down to the finest dust. During an eruption, gravitation and the force of the wind effect a separation of the fragments according to their sizes. The largest of them fall back into or close around the crater, the small pieces are thrown further, while the finer particles are borne off by the wind and gradually deposited from it, the coarser particles first, and ultimately the finest dust, which is

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* Bronns Jahrbuch, 1855, 72

† Epochen der Natur, p. 812.

"often carried off several leagues from the volcano. This fine "dust is termed volcanic ash, and furnishes the principal material "for the formation of the layers of tuff which are so abundant in "volcanic districts. The fragments of lava possess at the moment "of their ejection from the crater very different temperatures. "Some of them, especially at the commencement of the eruption, "are scarcely warm, and possess the dark colour of scoriæ; others "in greater quantity are red and white hot—the latter remain for "a short time fluid and perfectly plastic, form themselves into "rotating ellipsoids, or adopt some times abnormal long drawn "forms. These latter singular pieces have been termed volcanic "bombs. Decreasing in size, and becoming mixed with small "angular fragments, they graduate into what has been called by "the Italians, Lapilli, or volcanic sand." *

When the eruption has reached its climax, and the whole of the crater to a certain level has become filled with lava, the latter breaks out from beneath the dark crust that generally overlies it, at the lowest point of the bank of the crater, and rolls down the sides of the volcano, forming what appears as a stream of fire by night, and a thick viscid stream of slag by day. The lava leaves the crater red hot and as fluid as melted metal, but shortly afterwards the stream cools and becomes solid on the surface, while it remains for a long time fluid in the inside, the heat there hidden showing itself here and there through the cracks in the solidified crust. As the stream rolls on, these cracks close up, while others form at other places. "The whole surface is in continual motion; at "one point large bubbles are observed swelling up, which finally "burst and leave their rugged sides behind standing erect in "the most curious forms; at another point cakes of slag in the "most varied positions are carried along ploughing furrows as "they go, or tearing half fluid lava with them and drawing it out "and winding it round in curious rope like forms (the so called rope "lava). At some points the surface folds itself into deep cylin-"drical canals, which run on beside each other and parallel with "the direction of the stream; and at others, crossfolds and depres-"sions are formed. Thus these lava streams present, in that part of "their course where this struggle between their fluid interior and "the solidified crust has taken place, an extraordinarily wild and "rugged appearance." †

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* Die vulcanishe Gesteine in Sicilien und Island, p. 155.

† Naumann, Lehrbuch, I, 161.

According as a fused silicate cools more or less slowly, the structure of the resulting rock becomes more or less crystalline. No lava shows on its suface distinct mineralogical characters. Although traces of felspar or augite crystals make their appearance sometimes, they are nevertheless rendered unrecognizable by pieces of slag, the cavernous structure of the rock, atmospheric influences, etc. The non-crystalline character of the lava crust is of course attributable to its having been rapidly cooled. The great stream of 1669 from Etna, which is often 60 feet thick is at several places in the neighbourhood of Catania intersected by quarries, in which the structure of its various parts may be studied. It is only at the depth of several feet, that the lava begins to be compact and homogeneous. It here consists of a light gray felspathic mass in which crystals of black augite and grains of green olivine are disseminated.* Many trachytic lavas of recent production possess distinctly crystalline characters containing in the compact mass crystals or grains of glassy felspar (sanidine).

From this sketch of various volcanic processes it would appear, that there are being formed at the present day rocks entirely analogous to the basalts and trachytes, which have protruded themselves almost uninterruptedly through the earth's crust since the commencement of the tertiary period. We observe them solidifying from a condition as undoubtedly igneous as that of the slags which flow from our furnaces, and we observe them generally assuming the form of streams radiating from volcanic craters or as layers on the more horizontal ground around these, which latter form of deposition forcibly reminds the observer of the basaltic layers of much earlier date and non-volcanic origin. Lava is not so frequently observed in the form of veins as are the earlier trachytes, nevertheless it is sometimes observed in this form on the sides of craters. The earlier eruptions of trachytic and basaltic rocks seem to have taken place through fissures in the earth's crust. somewhat in the same manner as the older eruptive rocks. The masses thus erupted assumed the form of isolated dome shaped hills or wide extended coverings or even of whole stratified systems. In later periods we find these rocks gradually associating themselves with volcanic openings and occurring in the form of lava streams, many of which are even traceable to the craters, which emitted them. Fissures seem to have become more difficult of formation in the crust of the earth and in their place those canals of eruption seem to have been developed, which terminate on the surface of the earth in the craters of volcanoes. The transition from the earlier massive forms of deposition to the present peculiar volcanic type is so gradual and evident, that it is impossible to ascribe the former to any other cause than that from which the latter has been derived. Moreover it is impossible to discover any lithological difference between the trachytes of many lava streams and other rocks of the same class, which occur constituting whole mountain masses.

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* Sart. Von Waltershausen : Gesteine in Sicilien und Island, p. 100.

It is further a very remarkable circumstance connected with basaltic intrusions that they have exerted upon the neighbouring strata effects which could only have been produced by great heat. These effects, such as the re-crystallization of limestone, the carbonizing of coal, etc., are too well known to require particularisation. Another fact which speaks for the igneous origin of basalts is the following :—In many basaltic veins their sides or selvages are composed of a crust of glass or slag, which gradually alters towards the centre of the vein into the granular rock. This circumstance is entirely analogous to that observed in many slags. These are often quite vitreous on the surface where they have cooled quickly, while beneath they assume a granular and even crystalline texture.

In the first part of this paper I have referred to the chemical composition of certain rocks of the trachytic and basaltic groups. The analyses there given were however of the extremely siliceous trachytes and basic basalts. In Bischof's Chemical and Physical Geology there are recorded 27 analyses of trachytes containing from 52·8 to 72·24 per cent. of silica and averaging 62·91 per cent. In the same work there are given 22 analyses of dolerites and basalts, the content of which in silica ranges from 32·5 to 52·96 and averages 76·16 per cent. For the sake of completeness I insert here a list of the various species of the trachyte and basalt families as given by Cotta, preparatory to adverting to certain peculiarities in the structure of some of them, which peculiarities will again be referred to towards the close of the present chapter in discussing the relation which exists betwixt granite and gneiss.

Massive Trachytic Rocks.

Name.	Mineralogical constituents and principal characters.
Trachyte,	Sanidin (glassy felspar) and albite with hornblende or mica—granular.

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* Cotta: Gesteinelehre, p. 78.

Trachytic porphyry,	Impalpable fundamental mass with crystals of sanidine, &c.
Perlite,	Enamel-like mass—globular.
Obsidian and pumice stone,	Vitreous mass—impalpable to porous.
Phonolite,	Impalpable schistose, fundamental mass
Andesite,	Friable mixture of albite, oligoklase, hornblende and magnetic iron ore.

Tufaceous Trachytic Rocks.[*]

Name.
Trachytic-breccia.
Trachytic conglomerate.
Trachytic tuff.
Phonolotic conglomerate.
Pumice stone tuff.
Trass.
Pumice stone boulders.
Pumice stone sand.
Alumstone.

Massive Basaltic Rocks.[†]

Name.	Mineral constituents and general characters.
Dolerite,	Augite and labradorite, granular. phanero-crystalline.
Anamesite,	Augite and labradorite, constituents crypto-crystalline.
Basalt,	Augite and labradorite, impalpable, crypto-crystalline.
Nepheline dolerite,	Augite and nepheline, granular to impalpable.
Leucitrock,	Augite and leucite, granular to impalpable.
Analcimite,	Augite, labrador, analcime, do.

Tufaceous Basaltic Rocks.[‡]

Basalt conglomerate.
Basalt tuff.
Piperine.
Palagonite tuff.

The rocks above mentioned belong to a class, the igneous origin of which is regarded by geologists generally, as controvertibly established. Nevertheless there are to be found among them instances of rocks possessing a characteristic hitherto almost exclusively ascribed to those of sedimentary origin. This is no other than the arrangement of some of the constituents of these rocks in a direction parallel to certain planes or lines. There exist numerous instances of undoubtedly igneous rocks possessing parallel structure as marked as that of many sedimentary rocks. Many trachytic porphyries possess this, especially those from the Island of Ponza and Palmarola, from the foot of the Oyamel in Mexico and from the mountain Pagus near Smyrna.* Hoffmann also describes a trachyte from the Island of Pantellaria betwixt Sicily and Africa which consists of a light greenish grey compact fundamental mass with crystals of sanidine and another mineral, which by their form, position and distribution occasion a marked schistose structure. Trachytes of this nature have been observed in the Island of Basiluzzo betwixt Stromboli and Lipari, and in the Duchy of Nassau.† Slaty trachytes are also of frequent occurrence and have been observed by Leopold von Buch at Angostura and near Perexil in Teneriffe, and in the Canary Islands at the Caldera of Tiraxana and at Mogan on Grancanaria. Also by Burat in Velay, especially at St. Pierre Eynac at the Pas-de-Compain and in the Monts-Dores.‡ The slaty trachytes described by Burat are classed by other geologists among the Phonolites, which latter also furnish most remarkable instances of parallel structure among igneous rocks. Phonolites as a class possess this slaty structure, which is caused by the parallel position of the tubular looking crystals of felspar contained in it and on this account the rock can often be split up into slates and flags. This slaty structure stands also in connection with the form in which these rocks have been deposited. In phonolitic mountains it is generally observed that the flags and the layerlike subdivisions of the rock corresponding to them are arranged around the axis of the mountain in a bellshaped system of strata, the inclination of the latter decreasing as the summit of the mountain is approached. This would seem to indicate that the parallel structure was occasioned by the flow of the phonolitic material from the opening in the summit over and down the sides of the mountain. This view is further supported by the fact that many lavas possess a marked linear parallel structure, sometimes combined with an evident distension of their crystalline constituents in a direction parallel with the course of the lava stream. According to Spallanzani and Dolomieu this phenomenon is of great importance, since it was doubtless occasioned by the moving forward and the distension of the half-fluid lava, an explanation amply confirmed by the elongation in the direction of the stream of the cavities filled with gas which are contained in the lava. In the Leucit-lava of Borghetto the crystals of Leucit in spite of their tesseral form are even drawn out in the direction of the stream.* These instances of parallel structure among the trachytic and basaltic rocks have been specially dwelt upon, because of the analogy they present to gneiss and other schistose rocks of the primitive gneiss formation.

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[*] Naumann: Geognosie, p. 709.

[†] Cotta; Gesteinlehre, p. 34.

[‡] Naumann: Geognosie, I. p. 712.

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* Lehrbuch, I, 632.

† Lehrbuch, I, 634.

‡ Lehrbuch, I, 635.

Porphyry, Greenstone, and Melaphyr.—It has been already mentioned, that the trachytic and basaltic rocks first make their appearance about the commencement of the tertiary period. Instances of such rocks occur however even earlier in the trias formation, in passing backward through which we find that their character gradually changes. Porphyries result on the one hand, and melaphyrs, or commonly called traps, result on the other. The rocks usually comprehended under the name melaphyr are, according to Cotta, of a very indefinite character, and resolvable partly into basalt, partly into greenstones, and partly into porphyrites (porphyries free from quartz). On this account it would appear advisable to classify most of the eruptive rocks, which have been protruded during the Silurian, Carboniferous and Permian periods into two great divisions, viz: porphyries and greenstones. With regard to the igneous origin of these, I cannot do better than quote the argument of Naumann.† "We "have seen, that if the rocks of the lava family (as no one doubts) "must be regarded as pyrogenous formations, then the rocks of "the basalt and trachyte families have a similar origin. If now "the melaphyrs (or traps) are compared with the basalts, and "the felsitic porphyries with the trachytic porphyries, an astonishing similarity will be observed to exist between them; a "similarity which renders it often quite impossible to distinguish "the one from the other, when hand specimens of them merely "are examined. According to Bergmann and Delesse, we may "recognize the same mineralogical constituents in melaphyr as in

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* Lehrbuch, I, 468.

† Lehrbuch, I, 737.

" dolerite, anamesite, and basalt. It shows quite similar amygdaloidal forms to those of the latter rocks. It is a massive " rock sometimes with columnar development, a completely non-" fossiliferous rock like basalt. All these coincidences, from a " lithological point of view alone, appear completely to justify the " view, that the melaphyrs like the basalts must be numbered " among pyrogenous rocks. In the felsite-porphyries, it is true that " common orthoclase takes the place of the glassy felspar of the " trachytes, still the difference betwixt these two minerals must " be looked upon as trifling, especially when it is remembered, that " most orthoclases contain some soda besides the potash. More-" over, the remaining constituents, albite, oligoclase, mica, and " quartz are common to the trachytic-porphyries and to the " andesites, as well as to the felsitic-porphyries, while the labra-" dorite brings certain porphyrites in very close relationship to the " melaphyrs, from which they are sometimes almost undistinguish-" able. The unprejudiced enquirer will therefore surely without " hesitation regard the felsitic porphyries as rocks quite analo-" gous to the trachytic porphyries, with which they also " correspond in many other properties. There are also other " rocks, regarding the origin of which we must come to similar " conclusions. The diabases consist essentially of oligoclase or " labradorite and pyroxene; the diorites of albite, hornblende, " and quartz; both classes therefore of exactly the same minerals " as we observe occurring in lavas, basalts and trachytes. In " mineralogical and chemical respects therefore, no objection can " be taken to the supposition that they have been formed in a " manner exactly similar to these latter rocks. When we add to " this that these greenstones are always completely non-fossiliferous, " generally massive and supplied with structures and forms of " deposition quite similar to those of the basalts and lavas, the " above supposition would appear to be in every respect justifi-" able." With regard to the chemical composition of these rocks we find, that if we take the analysis of three hornblendic porphyries, and of a similar number of felsitic porphyries, as given in Bishop's Chemical and Physical Geology, the contents of silica of these will range from 77.9 to 59.87 and average 67.77 per cent. If we further take the analysis of greenstones and melaphyres contained in the same work, we find their percentage of silica to range from 55.29 to 42.72, and average 50.9.

The porphyries seem to have been formed principally during the Carboniferous and Permian periods. They often occur in the midst of granites and syenites, in which they form veins, so that they are generally newer than these latter rocks. A few of them are decidedly older than the coal period, and several have been formed simultaneously with the Bundtsandstein of the Triassic, and even in the Jurassic and the chalk formations, but the height of their development falls in the Carboniferous and the first part of the Permian period, in the German Rothliegendes. In the latter formation the porphyries have played a very important part, furnishing the material for many of its sedimentary rocks, and dislocating its strata considerably by their intrusion. In the carboniferous system porphyries break through and materially disturb the strata, forming veins or dykes, and inserting themselves horizontally as layers. While, as we have already mentioned, the basalts and trachytes exert a powerful chemical action on the rocks with which they come in contact, the influence of the prophyries seems to have been almost exclusively of a mechanical nature. It seems as if the porphyritic material on its arrival in the upper parts of the earth's crust did not possess such a high temperature or such a great degree of fluidity as the basalts. On the other hand, the rocks broken through by the porphyries, show evidence of the enormous violence to which they have been subjected, huge pieces having been broken off, surrounded by the porphyritic material, carried off by it and crushed and pulverized in its further progress. In this way have been formed the numerous breccias which occur in veins and masses of porphyry, where they adjoin the side-rocks. Sometimes the mechanical action has been so violent as to produce even a more finely divided material, which in the form of a sandstone-like or clay-like substance constitutes the selvages of many porphyritic veins. By far the most conclusive proofs however of the enormous forces which were at work during the eruption of the porphyry, are to be found in the dislocations which whole systems of strata have undergone. The neighbouring beds have been raised up, folded and fractured, while friction-grooves, and surfaces worn smooth by the sliding of one mass upon another occur at the junction of the erupted rock with the neighbouring strata. These effects furnish almost as conclusive evidence of the igneous origin of the porphyries as the chemical changes on the adjacent rocks do, as to the igneous origin of basalt.

With regard to the greenstones, they seem to have made their appearance in very great profusion during the Silurian and Devonian periods, and even earlier, although in lesser quantity among the primitive slates. In the Carboniferous system, they are intruded almost as frequently as the porphyries; but towards the commencement of the Permian period, they seem to be replaced by melaphyres, which continue to be erupted even as late as the Triassic period. The circumstances attending the protrusion of the greenstones and melaphyres are essentially the same as in the case of the porphyries. The strata which the former have broken through furnish abundant evidence of the extraordinary force which ejected them, and the dislocated strata also occasionally furnish proofs that they have been chemically acted on by the plutonic rock. This latter is especially the case with the melaphyres, which have frequently carbonized the coal and hardened the clay slates with which they have come in contact, in the same manner as more recent eruptive rocks. In the following tables will be found the names and characters of the rocks referred to in this paragraph.

Massive rocks of the Porphyry class.[*]

NAME.	CRYSTALS OCCURRING IN THE PASTE.	CHARACTER OF THE PASTE.
Quartz porphyry.	Quartz and Feldspar.	Yellow, brown and red colored.
Syenitic porphyry.	Quartz, Chlorite Feldspar, sometimes Mica.	Brown or green; somewhat granular.
Granitic porphyry.	Quartz, Mica, Feldspar.	Sometimes granular.
Micaceous porphyry.	Mica and Felspar.	Brown coloured.
Minette.	Mica and Felsite.	
Hornblendic porphyry.	Hornblende & Feldspar.	Dark coloured.
Felspathic porphyry.	Feldspar.	
Felsite rock.	Sometimes Quartz.	Yellowish, reddish, or greenish-grey.
Pitchstone, and Pitchstone porphyry.	Glassy Feldspar, Quartz and balls of Felsite.	

Rocks made up of Porphyritic debris.[†]

Porphyry breccia.
Porphyry conglomerate.
Porphyry sandstone (psammite.)
Porphyritic tuff or felsite tuff. Claystone.

Massive rocks of the Greenstone and Melaphyre class.[‡]

NAME.	ESSENTIAL CONSTITUENTS.	TEXTURE.
Diabase.	Augite, Labradorite, and Oligoclase.	Granular, porphyritic and slaty.

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[*] Cotta, Gesteinslehre, p. 97.
[†] Naumann, Lehrbuch, I, 706.
[‡] Cotta, Gesteinslehre, p. 47.

NAME.	ESSENTIAL CONSTITUENTS.	TEXTURE.
Calcareous Diabase.	Augite, Labradorite or Oligoclase & Calcite.	Granular impalpable, slaty concretionary.
Gabbro.	Diallage or Smaragdite with Labradorite and Saussürite.	Granular, slaty and concretionary.
Hypersthenite.	Hypersthene and Labradorite.	Granular.
Augite-rock.	Augite.	Granular to impalpable.
Norite.	Hornblende and Feldspar Hypersthene and Feldspar.	Granular.
Diorite.	Hornblende and Albite	Granular, slaty.
Globular Diorite.	Hornblende and Anorthite.	Granular and globular
Micaceous do.	Hornblende, Oligoclase. Orthoclase and Mica.	Granular.
Hornblende rock.	Hornblende.	Granular or impalpable.
Hornblende-slate.	Hornblende.	Slaty.
Actynolite slate.	Actynolite.	Slaty.
Kersanton.	Horblende and Mica.	Granular.
Eklogit.	Smaragdite and Garnet.	Granular, slaty.
Disthene rock.	Disthene with Garnet and Mica.	Granular, slaty.
Aphanite.	Feldspar and Pyroxene or Amphibole.	Impalpable, porphyritic, slaty, cellular, amygdaloidal.
Serpentine.	Serpentine.	Impalpable, porphyritic slaty.
Schiller rock.	Schillerspar and Serpentine.	Granular.
Garnet rock.	Garnet, Hornblende, and Magnetite.	Granular.
Eulysite.	Garnet, Pyroxene, and iron oxide.	Granular, impalpable.
Epidosite.	Pistazite and Quartz.	Granular, impalpable concretionary.
Labrador rock.	Labradorite and Hornblende.	Granular, porphyritic.

*Fragmentary rocks of the Greenstone and Melaphyre class.**

Greenstone conglomerate and greenstone breccia.

Greenstone sandstone (psammite.)

Greenstone tuff.

Schalstone.

It will be observed from the foregoing tables, that by the action of water on the porphyries and greenstones rocks have been formed similar to the conglomerates and tuffs of the volcanic formations, and probably in a similar manner. Moreover just as in these formations we find among the massive rocks above enumerated many instances of undoubtedly igneous rocks possessing a slaty structure. Many feldsitic porphyries possess a streaked texture caused sometimes by bands of varying colour, and oftener by the arrangement of the quartz grains or crystals in parallel layers, or the presence of thin laminæ of quartz in the paste.* The instances of a similar modification of structure among the greenstones are very numerous, and they are even more important as showing more clearly the cause of this structure among igneous rocks. The diorites usually occur in the form of veins, irregular masses (typhonische Stöcke,) and layers. The veins sometimes exhibit the following remarkable phenomena. In the middle they consist of granular diorite, and at the sides of slaty diorite or hornblende slate, a gradual transition being generally observable from the granular to the stratified rock. Somewhat similar instances of this nature have already been referred to in the paragraph concerning the basaltic rocks. The cause of these phenomena may most reasonably be sought for in the circumstances attending the cooling of the rock, and they are most likely the same as those which occasioned a similar structure among the porphyries. The fluid rock of the diorite vein was probably in motion in the centre, while the parts adjoining the side walls were solidified. The current in the centre would have a distending and arranging action at the junction of the fluid with the solidified parts, and an elongation and parallel grouping of the minerals there being formed would be the consequence. Not only has this slaty texture been observed in connection with veins, but it has also been remarked, that the more irregular masses of diorite assume a slaty structure towards their junction with the other rocks, the stratification being, as in the case of the veins, parallel with the line of such junction. Naumann adduces numerous instances of this sort;† and from a former paper of mine it will be observed, that they often occur in Norway.‡ Among the melaphyrs or traps the same circumstance is often remarked. In the melaphyr region south of the Hundsrück this rock, when it occurs in veins, often possesses a degree of parallel structure sufficient to cause it to separate into flags, which lie parallel with the walls of the vein. The trap of Kerrera decribed by Macculloch is another instance of slaty texture in trap veins. In this case the rock constituting the sides of the vein is filled with scales of mica, which all lie parallel to the enclosing walls. The same author also remaks concerning the hypersthenite of Sky, that the crystals of hypersthene " are laminar and " placed in a position parallel to each other, and as in gneiss to the " plane of the bed in which they lie." Another peculiarity, which shews the influence of igneous flow on the structure of a rock is the following : The amygdaloidal varieties of melaphyr sometimes possess an arrangement of their cavities corresponding to that possessed by the gas bubbles of lavas. They are often elongated,in which case their longest axes lie parallel to each other, and we may suppose as in the case of lava, to the direction of the flow of the igneous material.

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* Naumann, Lehrbuch, I, 703.

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* Lehrbuch, I, 616.

† Lehrbuch, II, 403.

‡ Canadian Naturalist, VII, 115.

Granite and Syenite.—These formations include the oldest eruptive rocks, the granites and gneiss-granites, which during the primitive period seem to have broken through the comparatively thin crust of the earth then existing. Later granitic eruptions seem to have taken place with great frequency throughout the Silurian, Devonian and Carboniferous periods, after which they gradually disappear. Syenite does not seem to appear in the Primitive Gneiss formation until long after the first general dislocation of the same and the protrusion of the granite had taken place. The principal syenitic eruptions seem to have occurred during or shortly after the deposition of the Silurian and Devonian rocks, although there are many instances of much younger syenites. The rocks appear after their protrusion to have assumed all the forms of occurrence, which we are accustomed to observe in plutonic and even volcanic formations ; irregular masses, covers, (nappes), layers and veins ; every form except the stream of the volcanic rock. But it is to be remarked that instead of veins or dykes being the most common form, as in the newer plutonic formations, the irregular masses preponderate. These masses are not to be confounded with the covers or cap rocks of the basalt and trachyte formations. They are huge islands of granite as it were, possessing generally an elliptical shape, and occurring in the midst of stratified rocks, which are sometimes vertical, and which often lean against the granite as if it were the immediate cause of their inclined position. One of the most important phenomena observable with regard to granite in all its forms of occurrence is the extent to which it contains huge masses and smaller fragments of other rocks. This is one of the most conclusive proofs of the power of the forces at work during the protrusion of the granite, and taken in connection with its forms of deposition furnishes incontrovertible evidence of its eruptive origin. Among the objections which have been made to this view, the most important is that founded on the circumstance that the quartz of granite has been the last of its constituents to solidify. Many theories have been proposed to account for this circumstance but it would seem necessary before attempting its explanation to enquire whether this alleged behavior of the quartz is really the fact. It is doubted by a few geologists, and altogether denied by Sartorius von Waltershausen, who remarks that according to his experience in the primary rocks especially in granite as well as in the volcanic rocks, quartz corundum and periclase have always first been separated. "For instance," he says, "I have minutely examined the granites from "Baveno, from various districts of the Grimsel, from Mont Blanc, "from the Oker valley (Harz), from the Island of Mull and many "other places, and those rocks show that the quartz solidified "first, then the mica and finally the feldspar."* In the face of such a distinct statement it might not be safe to regard as thoroughly established the fact whereon the above objection to the eruptive origin of granite is founded.

With regard to the chemical composition of granite, its content in silica, according to 18 analyses mentioned by Bischof, ranges from 63.3 to 76.02 per cent., and averages 69.33 per cent. Only two analyses of syenite are on record, the silica being estimated as 61.72 and 66.39 per cent.; average 64.05. If we compare these figures with the average content in silica of other eruptive rocks we find generally a diminution in the quantity of silica as the rocks become more and more recent, provided always that their classification into two great series of siliceous and more basic rocks is kept in sihgt. Thus the acid series comprehend:

Granites	69.33	per cent.	of silica.
Porphyries	67.77	"	"
Trachytes	62.91	"	"

The basic series on the other hand consist of:

Syenites	64.04	per cent.	silica.
Greenstone and Melaphyrs	50.65	"	"
Dolerites and Melaphyrs	46.16	"	"

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* Die Vulcanische Gesteine, &c., p. 225.

Bunsen and Streng are inclined to extend the theory of the normal trachytic and basaltic magmas, mentioned in the first part of this paper, so as to include the plutonic rocks, and to maintain that granites, porphyries and the older eruptive rocks are capable of being also regarded as mixtures of the two hypothetical melted masses. Of course the same objections which apply to this theory so far as basaltic and trachytic rocks are concerned, apply also in the case of the older rocks. On the other hand von Waltershausen's theory, also previously described, furnishes a complete explanation of the cause of the more siliceous character of the older rocks. The same increase of density and of basic constituents, which he supposes now to take place from the surface to the centre of the earth, existed in the oldest geological periods. The fused material, which, on breaking through the earth's crust solidified to granite, was the uppermost concentric layer then existing. It was lightest in weight and richest in silica. Beneath it lay successive layers graduating into each other, and with the depth increasing in density and basic constituents. But according to this theory, the magmas from which granites, porphyries, and trachytes resulted ought to have had a position nearer the surface than the fused matter which on its eruption yielded syenites, greenstones, melaphyres, and basalts. Hence the former rocks ought to have been the first to appear upon the earth's surface. Porphyries ought to have preceded syenites, and trachytes ought to have broken through the earth's crust and solidified prior not only to basalt but to greenstone and melaphyre. This is, however, not the case, and Sartorius von Waltershausen fully appreciates the difficulty, mentioning that the trachyte of Esia near Reikjavik, " which according to its mineralogical character " belongs to a higher-lying zone nevertheless intersects in the " form of a vein the strata of Iclandic trap, which in general " originate from deeper regions."* To explain the difficulty he resorts to the theory " that the earth's crust possesses different " thicknesses in different places, or that the surface of separation " between the already solidified and the still fluid masses represents " a relief turned inwards, of mountains and valleys. Now where " such a mountain accidentally reaches down into greater depths, " melted masses might be able, through fissures in it, prematurely " to escape to the surface, which masses might be broken through " later by rocks of higher zones which had remained longer fluid.

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* Die Vulkanische Gesteine, etc. p. 337.

" The anomalies in the Esia trachyte formation might perhaps " also be explained by movements of the fluid matter in the " interior, or by alterations in the relief forms of the surface of " separation just mentioned." The method of explaining these anomalies by movements in the fluid matter existing beneath the crust would appear to be the most reasonable, and I shall endeavour as briefly as possible to refer to it more minutely.

We have already seen in referring to the cause of earthquakes and volcanic eruptions, that it is not impossible that movements take place in the interior of the earth similar to tides in the ocean on its surface. We shall suppose the two lines within the dark coloured crust in the subjoined figure (1) to represent respectively the normal limits towards the interior of the acid, and the more basic melted matter, which in the earliest periods as now, may be supposed to have graduated into each other and yielded all the varieties of eruptive rocks now visible on the surface. We shall

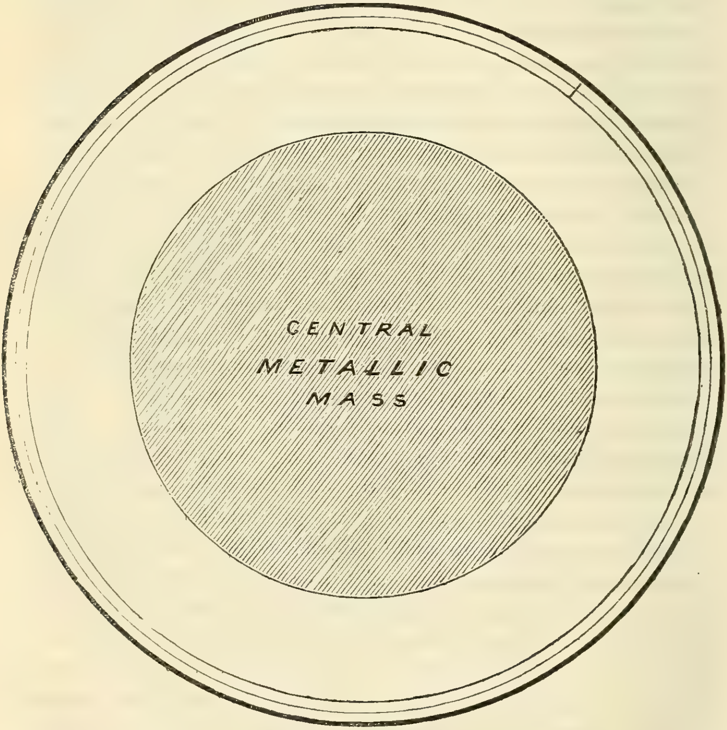

Fig. 1.

suppose further that a change comparatively slight takes place in the position of the metallic centre. It is evident that the consequence of this would be to press the higher zone against the solidified crust, and further to each side, bringing the lower zone in contact with the crust at *a*, as shown in figure 2. If at this part of the crust there existed fissures or volcanoes, the denser *and more basic mass*, *b* would be erupted, while the acid mass, *c* would remain in the interior. As soon, however, as the central mass resumed its normal position the conditions would be re-established for the protrusion of the more acid rock of the superior zone. In this way the alternate eruptions of highly silicified matter and then of extremely basic rock with all the innumerable gradations that exist between them, would seem to be capable of explanation. The amount of divergence of the metallic mass from the centre necessary to produce the effect

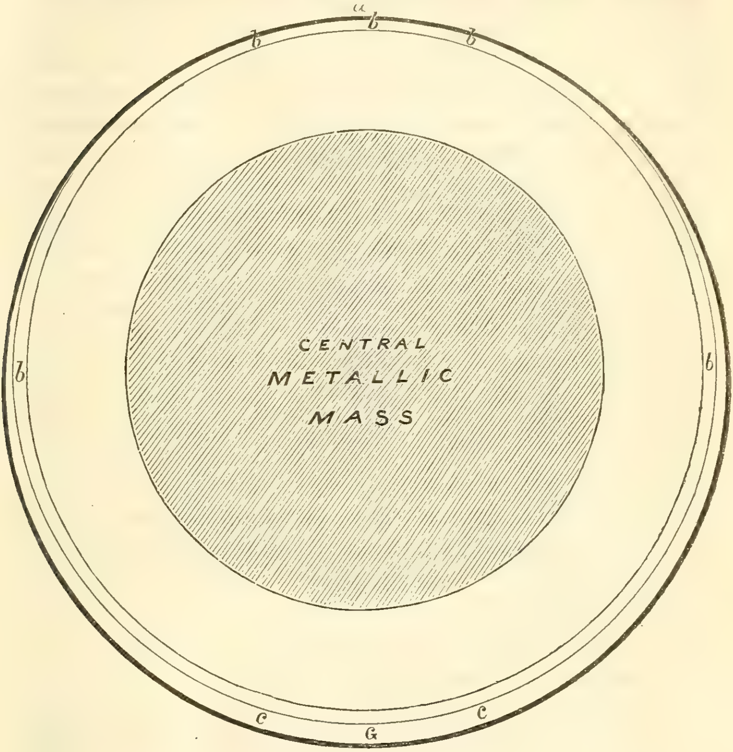

Fig. 2.

above described is so inconsiderable, that it does not appear unreasonable to attribute to the heavenly bodies the power of causing it. Still it would be very desirable if mathematicians would devote some attention to the subject.

The rocks of the granite family have been arranged by Cotta[*] according to their granular and slaty varieties, as follows:

ESSENTIAL CONSTITUENTS.	RESULTING ROCKS.	
	GRANULAR.	SLATY.
Feldspar and Hornblende.	Syenite.	Slaty Syenite.
Feldspar, Quartz, Mica and Hornblende.	Granitic Syenite.	Syenitic Gneiss.
Feldspar, Quartz and Mica.	Granite.	Gneiss.
Feldspar, Quartz and Talc.	Protogine.	Protogine Gneiss.
Feldspar, Quartz and Chlorite.	Chloritic Granite.	Chloritic Gneiss.
Feldspar, Quartz and Graphite.	Graphitic Granite.	Granitic Gneiss.
Feldspar, Quartz and Iron Mica.	Iron Granite.	Iron Gneiss.
Feldspar, Dichroite and Mica.	Dichroite Granite.	Dichroite Gneiss.
Dichroite, Mica and Garnet.	Dichroite Rock.	not known.
Feldspar, Elæolite and Mica.	Miascit.	
Feldspar, Quartz and Schorl.	Schorl Granite.	
Quartz, Schorl and Topaz.	Topaz rock.	
Oligoclase and Mica.	Kersantite.	Kersantite.
Feldspar and Quartz.	Granulite.	Granulite.
Quartz and Mica.	Greisen.	Mica slate.

The sedimentary rocks of the granite family are as follows:[†]

Granitic conglomerate.
Syenitic do.
Gneiss breccia and gneiss conglomerate.
Arkose (Feldspathic sandstone).

These latter rocks, however, bear but little analogy to the tufaceous rocks of later eruptive formations. Instead of being formed and deposited simultaneously with their corresponding massive rocks, they have generally been derived from the abrasion of these, long after their eruption and solidification, and deposited with the rocks of comparatively recent sedimentary formations. There do not seem to exist or have been formed with granitic eruptions any rocks of a tufaceous character. The obvious inference to be drawn from this circumstance is, that during at least the older granitic eruptions no water or ocean existed on the earth, from the conflict of which with the fluid granite such rocks could result. At the time of these eruptions, therefore, the temperature of the earth's surface must have been higher than the boiling point of water, and the whole of the latter now condensed on the surface must then have existed only in the atmosphere.

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[*] Gestein slehre, p. 114.

[†] Lehrbuch, I, 702.

With regard to the stratified varieties of granitic rocks it will be seen from the above table, that such have been abundantly developed. Even syenites occasionally possess parallel structure, as is the case of those of the Plauensche Grund near Dresden, of Ullern-Aasen, near Christiania, and of the Odenwald. A banded structure has been observed in the syenites of Brotterode in Thuringia, of Jurgojaskaja in Asiatic Russia, and of the Malvern Hills. Phillips regards this structure, in the latter instance, as having been produced during the original solidification of the rock.* He remarks that " the laminar and banded structures may be regarded as indications of crystallization under restraint, such restraint having reference to particular planes in consequence of the pressure of preconsolidated parts adjacent." One of the most important transitions observable among these rocks, however, is the stratification of granite, whereby it gradually assumes the character of gneiss. The most abundant and striking examples of this are to be found in the Primitive Gneiss formation, where granite occurs in beds between gneiss strata, and forms gradual but distinct transitions into these, by the laminæ of mica gradually arranging themselves parallel to each other, and parallel to the direction of the strata generally. But the irregular masses of granite to which we have already referred have also often been observed to assume a slaty structure as they approach the rocks adjoining them. One of the most remarkable examples of this occurs in the Primitive Slate formation of Upper Tellemarken in Norway, especially in the neighbourhood of Aamdal, Vraadal, Hvideseid, &c. In the interior parts of the granitic protrusion, the rock is thoroughly crystalline. Towards its limits, gneissoid granite is developed, the foliation of which is invariably parallel with the line of its junction with the adjoining rocks. That the rock here referred to is decidedly eruptive is proved by the numerous fragments of neighbouring slate enclosed in it.† Instances of exactly the same phenomenon have been observed near Taubenheim, in Saxony, and in the valley of the Schwarza, in Thuringia. At the latter place the granite is in the form of a long drawn mass, in the centre of which it is distinct and characteristic, while towards the hanging wall it graduates into gneissoid rock. The central granite or protogine of the Alps, according to Delesse, also graduates at its limits into gneiss, and this, according to Raymond and Charpentier, is the case with the colossal granite masses of the Pyrenees. These various instances furnish good grounds for maintaining that gneiss bears the same relation to granite, that diorite slate or hornblende slate bears to many granular diorites, the micaceous selvage of the Kerrera trap vein to its granular centre, and the numerous instances of stratified or banded porphyrites or trachytes, to the corresponding granular rocks. In short there would appear to be reason for assuming that gneiss is as much an igneous rock, as are the banded or stratified varieties of igneous rocks just mentioned. The instances just given prove at least that certain gneisses are eruptive, because they are nothing else than an outward covering, a contact modification of the eruptive granitic masses. There are, moreover, instances on record of gneisses occurring in veins, and sometimes enclosing fragments of other rocks. Humboldt mentions an instance occurring near Antimano, in Venezuela, where mica slate is intersected by veins from thirty-six to forty-eight feet thick, and consisting of gneiss filled with large crystals of feldspar; and Fournet maintains that in the mountains of Izeron, true eruptive gneisses occur in veins intersecting other gneissoid rocks.* Darwin relates that the granitoid gneiss of Bahia contains angular fragments of a hornblende rock, and that a similar gneiss occurring in Botofogo Bay, near Rio Janeiro, contains an angular piece seven yards long and two broad, of a very micaceous gneiss.† Instances of the same nature have been observed by Naumann near Ullensvang in Norway and by Boethlingk near Helsingfors in Finland.‡ The most satisfactory explanation which can be given of the formation of the gneissoid selvage to granitic masses is that which is given by Phillips in the case of syenite, and already quoted. It is a consequence of crystallization under restraint or pressure, accompanied by a movement of the solidifying mass somewhat in the same manner as indicated in the case of greenstone. Naumann adopts almost the same explanation in referring to the formation of igneous strata. His remarks on this point are as follows: "Let us imagine that an igneous mass crystallizing as it slowly cools, is confined between two parallel planes, which exert both pressure and resistance; the cooling, and consequently the solidification will commence at and proceed from these enclosing planes. Now, if in the solidifying mass the conditions exist for the development of many lamellar bodies (such as crystals of mica) then each of those bodies will, in consequence of the pressure, assume a position parallel with the enclosing surface, and the rock will be furnished with a plane parallel structure more or less distinct. If, further, the process of solidification does not progress regularly, but with periodic interruptions, then the rock would be divided into layers lying parallel to the enclosing planes. If the whole mass, during the progress of the solidification was in regular motion up and down, then there would be developed in each a linear parallel structure or distension of the rock more or less distinct."* Whether the parallel structure of the gneiss of the Primitive formation may be attributed to causes similar to those here indicated, is a question reserved for consideration in the third part of this paper. Meanwhile it may be remarked that the granite occurring in beds in that formation, between the zones or layers of gneiss is so intimately connected with the latter rock by lithological transitions that it would seem to be altogether inseparable from it, and that the same origin attributed to the one must belong to the other. In the gneiss-granite of the mountains of Lower Silesia, the granular and slaty modifications of that rock are, according to Von Raumer, regularly interstratified with each other. In Podolia, according to Von Blöde, granite and gneiss together form a whole, to which a contemporaneous and similar mode of formation is ascribable. In Scandinavia and Finland, in the central plateau of France, in Scotland, in Brazil, and Hungary the same relations betwixt granite and gneiss exist. "En Hongrie,"† says Beudant, "ces deux roches se montrent toujours ensemble et uniquement ensemble, elles ne forment pas des couches alternatives, mais une seule et même masse." If, therefore, granite, as we have seen, is undoubtedly igneous, then the primary gneiss must be of the same origin, and in this manner we obtain a proof of the original state of the igneous fluidity of our globe. Gneiss is the oldest formation, and if it can be reasonably shown to be igneous, then it must have been the rock first solidified; and previous to this, it, as well as all subsequent eruptive formations, and the material of all sedimentary rocks must have been in a state of igneous fusion. The theory of the igneous state of the original globe is, however, probably so well established as to require no further proof. It is an axiom without which it is impossible satisfactorily to account for the phenomena of volcanoes and hot springs, the elevation of mountains, the increase of temperature on penetrating into the earth, the phenomena of terrestrial magnetism, the formation of crystalline rocks, and the flattening of the earth at the poles. In the third and concluding part of this paper I shall advert more fully to this hypothesis, of the conditions which must have co-existed with the earth's original fluid state.

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* Mem. of the Geol. Survey of Great Britain, II. 1, p. 74.

† Dahll: Om Thelemarkens Geologie, p. 7.

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* Naumann, Lehrbuch, II, 180.

† Geological Observations on South America, p. 141.

‡ Lehrbuch, II, 113.

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* Lehrbuch, I, 496.

† Voyage en Hongrie, III, p. 19.

Art. XXV.—*Roofing Slate as a Source of Wealth to Canada. A visit to the Walton Slate Quarry;* by Robert Bell, C. E., of the Geological Survey of Canada, and interim Professor of Natural Sciences in Queen's College, Kingston.

The rarer treasures of the mineral world are not always those which yield the largest returns for the working. According to Darwin, it is remarked in South America, that " a person with a copper mine will gain ; with silver, he may gain ; but with gold he is sure to loose." Continuing this sort of comparison to the coarser mineral products, it could not be difficult to show that there are many of them which pay better, even than copper mines. In the midst of the excitement about copper and gold in the Eastern Townships, our valuable treasures in roofing slate have not been altogether overlooked. But before proceeding to point out the importance of this source of wealth, let us consider for a moment the value of slate quarries in other parts of the world, and ascertain how others turn their advantages, in this respect, to profitable account. The slate quarries of Wales are perhaps the most extensively wrought in the world. The Penrhyn Quarry, six miles from Bangor in North Wales, and owned by the Hon. Colonel Pennant, has been worked to a depth of nearly 900 feet by successive benches or chambers, each sixty feet below the next above. The lowest of these have been reached by sinking shafts and running horizontal adits or drifts, from which the material has to be raised perpendicularly. The cost of working is thus much increased, but notwithstanding this circumstance, the quarry is believed to pay nearly a hundred per cent. profit, and the annual net gains amount to upwards of £100,000. This quarry was opened about fifty years ago. It employs 2,500 men in the various operations connected with its working, and produces 13,000,000 slates a year. The Lanberris quarry employs 2,000 men and returns a net annual profit of about £70,000. The Welsh Slate Company's quarry, owned in part by Lord Palmerston, employs 400 men, and yields an annual profit of about £25,000. The Rhewbryfair Slate Company's quarry, gives employment to 350 men, and affords an annual net profit of £13,000, or fifty per cent. on the original capital. A quarry belonging to the Festiniog Slate Company is now being further developed, and it is proposed to make it furnish 50,000 tons per annum at a profit of £37,000 and a minimum dividend of from 30 to 40 per cent. These and other quarries, employing from 250 to 300 men, and yielding equally great returns, in proportion to their production, are situated on a slate band or "vein," as it is locally termed, in the Festiniog district in North Wales. There are besides, about a dozen other quarries in operation in Wales, all making the most satisfactory returns, when judiciously worked, although some of them have to contend against great difficulties, arising from the unfavorable underlie of the cleavage for working, or from disadvantages in the positions and locations of the quarries, some of which are between twenty and thirty miles distant from a port or railway. The slates are paid for at the quarries by the thousand, but the Welshmen reckon 1,200 to the "thousand." The Welsh quarries are estimated to produce an aggregate of from 350 to 400,000 tons of slate every year, of which fully one-half is furnished by the two first mentioned. The selling price of manufactured slates is about fifty shillings a ton, so that if the latter figure be correct, the yearly value of the slates produced in Wales, will be equal to a million of pounds sterling.

A cubic yard of slate rock weighs about two tons, and when we know the proportion to allow for waste in quarrying and dressing, we can calculate approximately the quantity of slates which can be produced in a volume of slate rock whose dimensions are given. As these dimensions can be ascertained in each case, the profits of slate quarrying may be reduced to a certainty, and thus it has the character of a sure branch of business—a great advantage over the more hazardous enterprise of mining. Some of the slate quarries in Wales have a horizontal surface of from 1000 to 2000 square yards, and are capable of being worked, in many instances, to great depths. It will presently be shown that some of the workable slate bands in Canada are very much more extensive.

In Britain all the best slate quarries have been opened long ago, and capitalists are now spending large sums in developing indifferent locations; still with proper management, fortunes are being made in working even comparatively new places. The large yearly profits derived from roofing slates have already enabled the owners of the quarries to amass immense sums of money, and the increasing demand, not only for roofing, but also for sanitary and other purposes to which slate has heen applied, foreshadows the brightest prospects for the future. Great as is the number of slates manufactured, the supply is not equal to the demand, and hence the producers have of late, been able to dictate all the terms and conditions of purchase to the buyers. The "rules and regulations" respecting the sale of slate at some of the quarries have very much the tone of the laws in the statute books.

Some quarries have orders booked for forty to sixty weeks in advance. In consequence of the enormous demand, prices have lately advanced several times, and if they were again raised 20 per cent, (says the Mining Journal from which these facts are principally derived) the sale would not be affected—so many new markets are continually opening. In addition to the rapidly increasing demand in Britain itself, orders for slates are sent from all parts of the world. Large numbers are constantly shipped to Russia, France, Spain, Germany, Denmark, Prussia, Austria and America, although the demand from the last mentioned quarter has not been so great for the last two years.

Slates, equal to those of Wales, are obtained in the west of Scotland and in the Delabole district, parish of Tintagel, in the north of Cornwall, where quarries are now worked paying 30 per cent. profit on the outlay. It would be needless here to enter into the merits of the slates of these regions, since my object is merely to shew the great value of this source of wealth in Great Britain, for which it is hoped the facts given in regard to Wales are sufficient.

The roofing slates of Great Britain and France belong to Lower Silurian strata, which are believed to be equivalent to the Quebec Group of this continent, and which comprises many of the slate bands of Eastern Canada and New England.

Since competition in the slate market of this continent, and perhaps also to some extent in that of the old world, is to be expected mainly from Vermont, it may not be uninteresting here to refer to the slate resources of that state. Three belts of slate rock occur in the state running southward down its eastern, middle and western portions. In the first, which keeps near the boundary of New Hampshire, the slate is of a dark color, and the cleavage generally corresponds with the planes of stratification. Although the belt has a great thickness, but little of it is available for working owing to contortions, the presence of foreign ingredients, imperfect cleavage and cross joints. An occasional band, however, is found to be suitable for roofing slates, and upon one of them the Guilford quarries are situated. The slates of this locality are sufficiently durable, but owing to their thickness, require a heavily timbered roof to support them. They are also liable to become rusty from the presence of oxide of iron. The situation of these quarries is such as to prevent their produce competing successfully with the slates imported from Wales. The slate bands in the eastern belt dip at high angles to the horizon, and thus have an advantage for working, over those of the western belt.

The middle slate belt extends from the Canada line at Lake Memphremagog about half way down the middle of the state. In places it is found to split into thin sheets, and is of a uniform color, —nearly black—differing in these respects from the slate bands of the eastern belt. Northfield, near the centre of the state, is the only place at which it has been worked. Here the price of slate delivered on the cars is $3.75 a square, or 50 cents more than Mr. Walton's price, on the Grand Trunk cars at Richmond. It may not be generally known that a square of slates is a hundred square feet, and that the greater the number required to make this area, the smaller the price per square.

The workable seams of the westerly belt are largely quarried for roofing and other purposes in the southwestern part of the state, where slate manufacturing forms a leading branch of industry. The slate is of a more uniform character than that of the eastern or the middle belt, and more exempt from foreign matter, which renders it capable of being sawn, as slab slate, and used for a great variety of purposes. The color of most of the western Vermont slates, like that of the Welsh, is dark purple, sometimes mottled with green spots. Bands of green, and sometimes of red slate are likewise found in this part of the state. Whatever may be the cause of the green spots in the purple slate, they form a very objectionable feature, being liable to decompose under the weather, and allow the rain to leak through the roof. A small speck of iron pyrites can generally be detected in the centre of each of the spots, and these may have had something to do with their formation. The slate quarries of western Vermont have a common disadvantage, in the low underlie of the cleavage, which in several cases is less than 20 degrees, thus requiring a much larger expenditure in working, than when the cleavage is vertical, or underlying at a high angle to the horizon. In some of the quarries the underlie, which is always to the eastward, is from 20 to 40 degrees, but unless the angle is sufficiently high to give a self-supporting hanging wall, a great loss is incurred in removing or supporting the superincumbent mass.

About a dozen quarries are worked on the western belt. The principal one is the Eagle Slate Quarry, situated a mile south of Hydeville, and which produces about 10,000 squares a year. Here the underlie of the cleavage, which nearly coincides with the dip of the strata, is at an angle of only 17 degrees. Roofing slates alone are made at this quarry, and bring from $2.50 to $3.50 a square at Hydeville depot. In the township of Castleton, the West Castleton Railroad and Slate Company manufacture 150 squares of slate a month, besides sawing from 15 to 16,000 square feet of slab slate. The cleavage here underlies to the eastward at an angle of 40 degrees. In 1857, the second year of operation, the sales of the produce of this quarry amounted to $60,000.

A planed surface of slate is found to retain remarkably well the compounds used in enamelling, even in the presence of heat or acids, and hence slab slate can be marbleized and used in a great variety of ways. The western Vermont slate is marbleized for jambs and mantelpieces, table and bureau tops, billiard beds and kerosene lamp bottoms. These are successfully made to imitate all kinds of ornamental marble, and are sold in immense numbers at one fourth the price of real marble. The cost of marbleized mantels varies from 10 to 125 dollars, according to the workmanship which has been expended upon them. Writing slates are also prepared in great numbers at the western quarries; and there is a large demand for unplaned slabs for sanitary and other purposes. The foregoing facts in regard to the slates of Vermont are condensed from Prof. Hitchock's report on the geology of the state.

In Canada, no clay slates have yet been discovered among the Laurentian rocks, the strata of this series which approach nearest clay slates in composition, being always massive, and usually of a crystalline character. Slaty rocks, approaching argillites, have been found in several places among the Huronian series. For example, specimens from the Montreal River, about five miles from its junction with Lake Temiscaming, have the characters of roofing slate, but the plates into which they split are scarcely as thin as desirable. Among these rocks, on the north side of Lake Superior, greenish-black and greenish-blue slates, some of which may be fit for roofing, are found on the Kaministiquia River above the Grand Falls, and slates which are said to be available for this purpose, occur on the Slate Islands, and at Anse à la Bouteille.

In Eastern Canada the argillaceous bands of the Quebec Group, in many places yield good roofing slates, which have already been successfully wrought in a few localities. The most important of these is the Walton Slate Quarry, in Melbourne, to be described further on. The Melbourne Slate band, in its northeastward extension, crosses the St. Francis River into Cleveland, where, in 1854, a quarry was opened on the 6th lot of the 9th Range, but after a time abandoned, from the band being too narrow to pay to overcome the difficulties in the way of working it. The slate produced was nearly black in color and of the best quality. The locality is on the Grand Trunk Railway, about three miles south of the village of Richmond. On the 4th lot of the 1st range of Kingsey, reddish-purple slates of a good kind are found in the high eastern bank of the St Francis River, about seven miles below Richmond Station. The Kingsey slates are not so hard and smooth as those of Melbourne and Cleveland. A Montreal company attempted to work this quarry, but abandoned it after grading a railway track down the bank of the St. Francis from the Grank Trunk at Richmond. The failure to carry out this enterprise, appears to have prejudiced Montreal capitalists against slate quarrying generally, and to Mr. Benjamin Walton remained the honor of first demonstrating its profitable nature, and of developing a great slate quarry in Canada—a quarry which is unsurpassed by any in the world, either in the quality of the slates produced, or in the facilities for working. The Kingsey slate band is continued into the Township of Durham, on the west side of the St. Francis, and has been worked to a small extent on the 6th lot of the 4th range. At the slate rapids on the Black River, on the 12th lot of the 10th range of Ely, an attempt was made some years ago to open a quarry on a band of very fossile bluish-black slate. The cleavage is vertical and strikes S. 56° W. Bands of apparently good roofing slate are met with on the 14th lot of the 1st range of Halifax, and further to the northeast, in the Township of Frampton. For some distance above and below the junction of the Rivière du Loup with the Chaudiere, good clay slates are largely developed. On the Rivière du Loup, half a mile above the junction, a band of the rock exceeding half a mile in breadth, would, in several places, afford good writing and roofing slates. A locality for slate occurs on the 18th lot in the 3rd range of Tring. In the continuation of the Quebec group to the northeastward, slates apparently fit for roofing, are found on the Marsouin River in the northern part of the County of Gaspé, a few miles back from the St. Lawrence. The above mentioned slate bands in the Eastern Townships also belong to the Quebec group of the Lower Silurian System. In the Upper Silurian rocks, on the 2nd lot in the 5th range of Orford, dark blue roofing slates are found, not unlike those of Melbourne, but less smooth in cleavage; and again on the 29th lot in the 5th range of Brompton, on what appears to be a continuation of the last mentioned band. Similar slates occur in West Bury on the St. Francis River. Blackish slates, which may be suitable for roofing, are met with among rocks of the same age on the Patapedia River in the county of Bonaventure. The information just given in regard to the slate rocks of Canada is to be found in the reports of the Geological Survey.

The Walton Slate Quarry.

A short time ago the writer accompanied Mr. Walton from Melbourne village on a visit to his slate quarry, and obtained most of the following notes respecting it when on the ground.* For the information of those not acquainted with the geography of this part of the country, it may be stated that Melbourne is on the west side of the St. Francis River opposite to Richmond, from which the Grand Trunk Railway diverges in three directions—to Montreal, Quebec and Portland; the branch to the last mentioned, running or a number of miles up the east side of the river.

After a drive of three miles along the main road up the west bank of the river, we come to the quarry road, turning west at right angles, while the scow-ferry, by which the slates are conveyed to the railway depot on the other side of the river, lies on the left. Following the quarry road we ascend a steep incline all the way, which, although difficult to surmount, is, as Mr. Walton remarked, a necessary feature in order to have a good slate quarry. A strip of the woods has been cleared on either side to allow of the access of the sun and wind to dry the road. In making these clearings and constructing the road, the proprietor expended about twelve hundred dollars. At the end of about a mile, we come to the cluster of buildings attached to the quarry, and leaving our conveyance at one of the boarding houses for the employés, proceed to inspect the works.

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* Mr. Walton's property has been examined by Charles Robb, Esq. Mine Engineer, and his report, (an abstract of which was published in the Journal of the Upper Canada Board of Arts and Manufactures) has been consulted in preparing this article.

The quarry itself is not seen from the approach, being concealed by a band of serpentine which flanks the slate band on the north. It was found necessary to drive a tunnel, a hundred feet in length, from the slope of the hill through the serpentine, in order to expose a workable face of the slate rock behind. In front of the tunnel are the sheds for manufacturing the slate, and a dump or spoil bank, composed of the refuse from the dressing process. Beautiful specimens of asbestus are seen on either side in passing through the tunnel, from which we emerge on the level of the floor of the quarry and find ourselves in a great roofless chamber, the four walls of which rise to the height of seventy feet. The cleavage of the slate is about perpendicular, and runs in the direction of the greatest length of the quarry. As in the best quarries in other countries, the slate is found to improve in all the desirable qualities in descending, and the waste, due to surface influences, to diminish continually. Owing to the vertical cleavage, the surface influences have penetrated to an astonishing depth. In the upper forty feet the rock was injured to such an extent, that fully half the material quarried was wasted, and even at the present depth, the same influences are still discernible, but rapidly dying out.

At first the rock was so fissile that it could with difficulty be split into sufficiently thick sheets, but now the plates can be split to any required thickness with perfect uniformity and beautifully smooth surfaces. No difficulty is to be apprehended from imperfect cleavage in slate of this character, at the greatest depth to which the quarry can be worked. Since it is always found that in working a good band of slate the quality improves in respect to smoothness, regularity of cleavage, color and hardness, in going down, it will be perceived that a first rate quarry requires to have such a situation that it can be advantageously worked to a great depth. The great depth of the principal quarries in Wales is one of the reasons which cause the Welsh slates to be so highly prized.

The peculiarly favorable position of the Walton Quarry and the perpendicular cleavage of the slate, offer every facility for the most extensive and advantageous working. The top of the quarry is 451 feet above the St. Francis River at the depot, so that ample room is afforded for working by horizontal galleries driven from the side of the hill, thus avoiding all expense for pumping and hoisting. For future working, it is proposed to run an adit at a level of forty feet below the present one, and ultimately, one from the bank of the river at about 360 feet below the same level. From this last an almost unlimited supply of the finest slates might be taken out at the level of the railway. The quarry, in its present state, is capable of yielding 20,000 squares a year, so that the galleries referred to may be looked upon as work to be performed by another generation. It measures 24 yards in depth, 14 in breadth and 32 in length, giving a total of 10,752 cubic yards which have been excavated. The yield of slate up to the present time has been about 10,000 squares. The proportion of waste to manufactured slate has of course very much diminished in the lower portion of the quarry, and there now remain 381 feet between the bottom of the quarry and the level of the St. Francis, in which even better slate may be expected than that hitherto obtained.

The position of the quarry is about the centre of the 22nd lot in the 6th range of Melbourne township. The property to which it belongs comprises 1180 acres, extending in every direction from the quarry—as far as the railway, to the eastward—and including the ground around the depôt. The great band of serpentine in contact with the slate has a steep slope to the north, while to the south of the slate band, the ground falls away gradually, and the rock is seldom seen. The roofing slate has been ascertained to have a breadth of at least a third of a mile at the broadest place, and the whole of it appears to be equally good, as far as can be determined from surface trials. The quarry is situated on the widest part, and the band is traceable on the surface (westward from the river) for about a mile and a half; at the end of which distance it appears to be cut off by the serpentine, but reappears further on. East of the river, it is again met with in the strike, with a greatly reduced thickness. It was on this part of the band that the quarry in Cleveland, already mentioned, was opened.

The whole series in this neighbourhood is tilted to a vertical attitude, and strikes S. 45° to 55° W., or at right angles to the river. The serpentine affords many varieties of green and greenish-black marble, of which a few have been proved by Sir William Logan, to be of good quality; and the specimens in the Geological Muséum are generally admired. On the west end of the quarry lot, there occurs a bed of chromic iron, of the hard, dark, crystalline variety, worth fifty dollars a ton in the English market, containing, as it does, 53 per cent. of the sesqui-oxide of chromium.* It appears to be obtainable in sufficient quantities to work at a profit. On the north-east end of the adjoining lot (22 in the 5th range—part of the same property) vitreous copper ore is found along a crack or vein in the serpentine; and further on in the strike, larger deposits of copper ore are found in the township of Orford, associated with the same rock.

The average price of the Melbourne slates delivered at the railway is $3.25 per square. They are made by contract at the quarry at $1.75, leaving a difference of $1.50 per square. From this is to be deducted 25 cents for cost of carriage to the railway. All other contingencies are covered by 15 cents more, giving upwards of a dollar a square, or 50 per cent. as the net profit to the proprietor. It is to be observed, that this calculation of profit is based on the present working expenses, and makes no allowance for past expenditure or future development. The quarry is now brought into good working order, and, at the present rates the contractors are making large profits. It is calculated that in future, by a different system of working, the proceeds to the proprietor will be not less than 100 per cent. upon the cost after delivering on the cars.

It is scarcely necessary to notice the superiority of slates, both in regard to appearance and excellence, as a roofing material, over shingles, compositions, and even metals. The original cost of slate is about one-third more than shingles, although cheaper in the end; it is one-half less than tin and one-third less than galvanized iron. The reason of slate not being adopted in preference to these latter, is often attributable to prejudice, arising from examples where slates had been unskilfully employed. In our towns and cities they are now displacing these materials, and since good wood for shingles is becoming scarce in the agricultural districts, we may look foward to the time when slates will form the principal roofing material used in Canada.

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*Mr. Robb's analysis.

But outside of our own country, the market for slates is unlimited. For instance, after being sold at Richmond, at the large profits just mentioned, they can be delivered in Portland for $4.14 per square and sold in Boston and New-York at from $8 to $10. The western cities in the United States could be more easily supplied from the slate quarries of Eastern Canada than from any others and the prices in the old world are such, that our slate could probably be sent there and sold to advantage.

Among the desirable qualities of a good slate, are uniformity of color, smoothness of surface, durability and strength with lightness; all of which are possessed in an eminent degree by those of the Walton Quarry, the slates from it being equal to any in the world, They are of a bluish-black color, contain no carbonate of lime. are unaffected by acids and almost perfectly non-absorbent, and thus can, in no way, be affected by the weather. The rock is fine grained and splits with great facility when newly taken from the quarry, but the slates harden rapidly and acquire great toughness and strength. From analyses by Dr. T. S. Hunt, the Melbourne slates are shown to have a very striking resemblance in composition to those from Bangor in Wales, and also to those from Angers in France. Slates from the latter place have been exposed for a hundred years, without perceptible deterioration, on the roof of the seminary building at the corner of Notre Dame and St. François Xavier Streets in Montreal, which proves that a slate covering is well adapted to resist the influence of the Canadian climate.* It is to be regretted that no analysis of the Vermont slates is available for comparison, but the purple varieties are more liable than our bluish black slates, to fade and give the roof a checkered and unsightly appearance, and hence the latter are the more desirable, especially where artistic arrangement is required. While the bands or "veins" of workable slate in the principal Vermont quarries are said to be only about 18 to 24 feet thick, the Melbourne band has been ascertained to have a thickness of at least 1700 feet, opposite the Walton Quarry, and to occupy a surface area in this neigborhood of about a hundred acres. Such a volume of slate is practically inexhaustible, and judging from appearance it is all of a uniformly good quality. Mr. Walton contemplates manufacturing writing and slab slates at his quarry, for both of which the Melbourne band is admirably adapted.

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* Descriptive Catalogue of the Economical Minerals of Canada sent to the International Exhibition of 1862.

It may not be out of place here to describe the process of manufacturing the roofing slates at the Walton Quarry. The rock is blasted by experienced workmen, in such a way as to give regularly shaped masses, which are conveyed on a tram-way to the dressing sheds. Here, the blocks, fresh from the quarry, are split by a mallet and chizel into sheets of the required thickness and thrown into a heap ready for trimming. The slate dresser, who is seated, places the sheet upon a horizontal steel bar in front of him, and with a thick-bladed knife or cleaver, cuts off at a blow the part projecting over the edge of the bar, the knife and the bar forming, as it were, a pair of shears. The undressed sheets are received on the left side, and the finished slates piled on the right, each size being kept separate. Mr. Walton has adopted sixteen sizes, varying from 6 by 12 to 14 by 24 inches. From long experience, the slate dresser perceives at a glance the largest size that a sheet will produce, and in a second, trims two of its edges, and having marked off the other two with a measuring gage, squares them with two blows, the whole process being performed in a twinkling.

Mr. Walton commenced opening his quarry in 1860, and having himself every confidence in the undertaking, pushed it steadily forward, in the face of many obstacles, to the present successful result. The outlay incurred in buying and developing the property, amounted to about $36,000, but the quarry and all its machinery are now in a condition for profitable working for a long time to come. At first it yielded no adequate returns, and Mr. Walton was obliged to work on through many a dreary day, without sympathy or encouragement. It must therefore be a great satisfaction to him, that his most sanguine hopes have been realized. The quality of the slate has proved to be all that could be desired and the demand is already in excess of the supply, the proprietor having been obliged, just the other day, to refuse, amongst others, an order for a thousand squares. We admire the enterprise and perseverance, and rejoice at the success of the gentleman, who embarked his fortune, and bestowed his time and attention, to develop so important, but hitherto untried source of wealth to our country.

Melbourne, Canada East, October 8, 1863.

ART. XXVI.—*On the genus Stricklandia;—proposed alteration of the name;* by E. BILLINGS.

In April 1859, I described and published in this Journal a genus of fossil Brachiopoda under the name of *Stricklandia.* In the Geologist for the present month, there is a figure of a fossil plant under the name of *Stricklandia acuminata,* with a note by Mrs. Strickland directing attention to the fact that the species was figured in the geology of Cheltenham, and also on the title-page of the Memoir of the life of Strickland.

Of this I was not aware until reading Mrs. Strickland's note, never having seen the two works cited. As it will be inconvenient to have two genera with precisely the same name I propose to change my genus to *Stricklandinia.* The difference in the termination will be quite sufficient to distinguish the two, while no one can regret that H. E. Strickland should have two genera named after him.

ART. XXVII—*On some Mineral Waters of Nova Scotia;* by PROF. HOW, D.C.L., University of King's College, Windsor, N.S.

Little has yet been done in the chemical examination of the mineral waters of Nova Scotia from the want of a systematic geological survey of the Province. They are, as appear from the following notices and analyses, of varied character; and there would be much scientific interest in an extended and thorough investigation into their qualities and composition. At the same time, if the results were duly published, the medicinal virtues which reside in some of the waters would be made generally known; it is probable too that new medicinal springs might be discovered. This is obviously a matter of sufficient importance to the Province, both in a sanitary and economic point of view, to demand the care and attention of an enlightened government. Mineral springs have been and are still so frequently the sole means of rendering localities famous and wealthy by attracting residents for more or less lengthened seasons, that it is well worth while to possess any water of great curative value, and to make its merits known as extensively as possible. Nova Scotia appears to be able to add valuable medicinal waters to her mineral resources awaiting exploration and development. I propose in the following paper to give some facts about these mineral springs, and the results of my analyses.

Bras d'Or Saline Water, Cape Breton.—This water has an extraordinary and apparently well grounded reputation for procuring alleviations and effecting cures in various maladies; authentic cases being known of much benefit resulting from its use in rheumatism and severe headaches. A gentleman of high standing and of scientific reputation informed me that he had obtained a good appetite and increased strength by taking about five gallons of it; and by further use a moderation of the violence of asthmatic attacks to which he was subject; and in fact that its employment had proved a real blessing to him. A water possessing such qualities would of course be much resorted to, and it was considered worth while to erect a house for the accommodation of visitors soon after the merits of this water became somewhat known.

There appear to be three springs at this locality, situated "near Kelly's on the high road from Sydney to St. Peters, in a brook that empties into the Salmon River, distant some two or three miles from the source of the river, six or seven from the southern shore of the Bras d'Or lake." On referring to the map accompanying Dr. Dawson's Acadian Geology, at about the spot so indicated, Devonian and Silurian rocks are found to come in contact with syenite and other igneous rocks; and I have direct information that the water rises in syenitic rocks. The flow is said to be not more than a gallon in a minute. Whether all the springs become mingled in one stream I do not know; the analysis which follows was made on a quantity of the water most esteemed, I apprehend, for medicinal virtues. The amount at my disposal did not enable me to make a thorough investigation, so that no doubt I do not give all its ingredients. The results were calculated for the English imperial gallon of 70,000 grains.

The water was clear and of neutral reaction.

	Grains.
Iron and Phosphoric Acid	Traces.
Carbonates of Lime and Magnesia	0.60
Sulphate of Lime	0.94
Chloride of Sodium	343.11
Chloride of Potassium	4.55
Chloride of Calcium	308.90
Chloride of Magnesium	4.47
	662.57

Specific Gravity at 54° = 1007.397.

The carbonates of lime and magnesia were thrown down by boiling. It was assumed that two thirds of the precipitate thus obtained consisted of carbonate of lime, and the calculation made accordingly; the precipitate was so small that no great error could arise in this way. No iodine was detected in the saline residue from 1500 grains of the water.

The composition of this water is very remarkable, quantities of sulphates and carbonates so very small being rarely met with: the large amount of chloride of calcium is also very unusual. On looking over a large number of analyses of mineral waters, belonging to different parts of the world, I find none to resemble the present excepting certain Canadian waters analysed and described by Hunt.* These form the first of the six classes in which he has arranged the mineral waters of Canada, and are characterized by "containing chloride of sodium with large portions of chlorides of calcium and magnesium, sometimes with sulphates. The carbonates of lime and magnesia are either present only in very minute quantities, or are altogether wanting. These waters are generally very bitter to the taste, and always contain portions of bromides and iodides." It is also remarked, by the same authority,† that these brine springs are altogether unlike any hitherto studied; and particularly instanced are those of England, Germany, and the State of New York, in which the chloride of sodium greatly preponderates, and which are supposed to arise from the solution of rock salt. The brine springs of the Lower Silurian limestones (such as the Canadian waters in question), on the contrary, may be supposed, according to Hunt, to represent the composition of the ancient ocean, in which these early strata were deposited. I have mentioned that the Bras d'Or water is said to arise in syenitic rocks. Crystalline limestones may exist at the locality: I have seen them in some parts of the rocks of Cape Breton coloured of the same tint in Dawson's map.

II. Renfrew Brine Spring, Hants Co.—This spring flows near the gold diggings of this place. I found it to yield about 1439 grains of solid matter to the imperial gallon, consisting principally of chloride of sodium, with but a small proportion of earthy salts.

III. Brine Spring of River Philip, Cumberland Co.—A spring exists here affording a dry salt of good taste and colour; some pounds of which were sent to the Exhibition at London in 1862. No information was furnished as to the spring; it arises no doubt in carboniferous rocks, in which formation salt springs are known to exist in several parts of this and other counties. Nothing however has yet been done in their examination; and the River Philip spring is the only one, so far as I know, that has been turned to any account.

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* Report on Geology of Canada, 1863, p. 531.

† Loc. cit p. 563.

IV. Wilmot Springs, Annapolis Co.—These, situated about 100 miles from Halifax, afford a water which has been much resorted to. Rev. Dr. Robertson, rector of the parish of Wilmot, has obligingly furnished me the following information. "The water of the Wilmot springs is cold, with an abundant flow, and is highly charged with mineral substances, chiefly iron and copper (?) No correct analysis of it, I rather think, has yet been made. It is said to contain a small proportion of iodine. In former times the springs were much frequented, but of late years very few visitors have come to them. The water however is remarkably efficacious in curing cutaneous complaints or eruptions. In my own opinion the Wilmot springs deserve to be better known and more frequented than they are at present. If the proprietors were men of substance and energy, I have not a doubt but that their locality would be one of the best known places in all Nova Scotia."

V. *Thermal? Spring near Chester, Lunenburg Co.*—Amos F. Morgan, Esq., has furnished me with the following details of a spring of clear water issuing in the centre of a rising ground or small hillock in the woods in the neighbourhood of Chester. The temperature of the atmosphere at the time of finding the spring, in the beginning of March, was below the freezing point; but of the water, as far as could be judged, about that of new milk, the pool having no appearance of having been frozen over the whole winter. The basin filled with the water was considered to be about eight feet square. The mud at the bottom was covered with small holes about the size of a man's finger, and out of these rose continually bubbles of gas. The water tasted slightly bitter, or perhaps was imagined to taste so, but was peculiarly soft, so much so, that it felt more like oil than water in the mouth. It is possible that this water is decidedly thermal; and it would seem, from its described taste and oily character in the mouth, to be highly alkaline. The gas arising appears to be abundant. This water would be well worth investigation.

VI. *Spa Spring Water, Windsor, Hants Co.*—This is a water rising in a field in a district in which gypsum is one of the prevailing rocks, the geological age being Lower Carboniferous.

The water has long been considered chalybeate, and has been taken medicinally by a number of persons, with what effect I do not know. It is well known as a favorite drink for horses and cattle. The chalybeate character of the water was inferred from its possessing a strong inky taste, and also from a certain red deposit found in the conduit pipes through which it ran, both of which were justly attributed to the presence of iron. There is however very little iron in the water as it issues from its outlet, as is seen in the following analysis made of the water carefully collected in a small reservoir filled immediately from the spring rising beneath.

The water was perfectly colourless and clear; it had little taste, and that not inky; its temperature was 49° F., that of the air being 31°. It afforded the following constituents in an imperial gallon:

	Grains.
Carbonate of Lime	17.50
Carbonate of Iron	0.40
Carbonate of Magnesia	0.31
Sulphate of Lime	106.21
Sulphate of Soda	0.68
Sulphate of Potassa	0.38
Sulphate of Magnesia	11.02
Chloride of Sodium	0·90
Phosphoric Acid and organic matter	traces
Silica	0·60
Grains in a gallon	138.00
Free Carbonic Acid (1.35 cubic inch at 32°)	0.64
Specific Gravity at 49° Fah.	1001.858

This water would be placed in the sixth class of Hunt,* being rich in sulphates. The sulphate of lime (derived no doubt from the prevailing gypsum,) which is the characteristic ingredient, is present in larger amount in only one out of fifteen waters from Cheltenham in England, and is by no means a common constituent of waters in such large proportion. The water is known to possess purgative properties when taken freely, owing in part no doubt to the sulphate of magnesia present. The inky taste and the red deposit from the water are due to its action on the soil, and to its admixture with surface water, and are only observed when precautions are not taken to keep the spring-water pure. The chalybeate impregnation thus obtained is of course valuable, but will be subject to variation.

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* Report on Geology of Canada, 1863, p. 532.

From the well marked characters of the waters mentioned in this paper it is evident that, in a systematic survey of the Province, the inquiry into its mineral springs would form a very interesting and useful part of the work involved in so desirable an undertaking.

BRITISH ASSOCIATION.

SPEECH OF SIR WILLIAM ARMSTRONG.

The British Association commenced its labours for the year by the introductory speech from the President. Sir W. Armstrong spoke as follows:—*

Gentlemen of the British Association,—I esteem it the greatest honour of my life that I am called upon to assume the office of your President. In that capacity, and as representing your body, I may be allowed to advert to the gratifying reception which the British Association met with on their former visit to this region of mining and manufacturing industry; and, as a member of the community which you have again honoured with a visit, I undertake to convey to you the assurance of a renewed and hearty welcome. A quarter of the century has elapsed since the Association assembled in this town, and in no former period of equal duration has so great a progress been made in physical knowledge. In mechanical science, and especially in those branches of it which are concerned in the application of steam power to effect interchange between distant communities, the progress made since 1838 has no parallel in history. The railway system was then in its infancy, and the great problem of Transatlantic steam navigation had only received its complete solution in the preceding year. Since that time railways have extended to every continent, and steamships have covered the ocean. These reflections claim our attention on this occasion, because the locality in which we hold our present meeting is the birthplace of railways, and because the coal mines of this district have contributed more largely than any others to supply the motive power by which steam communication by land and water has been established on so gigantic a scale..

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THE COALFIELDS.

The coalfields of this district, so intimately connected with the railway system, both in its origin and maintenance, will, doubtless, receive much attention from the association at their present meeting. To persons who contend that all geological phenomena may be attributed to causes identical in nature and degree with those now in operation, the formation of coal must present peculiar difficulty. The rankness of vegetation which must have existed in the carboniferous era, and the uniformity of climate which appears to have prevailed almost from the poles to the equator, would seem to imply a higher temperature of the earth's crust, and an atmosphere more laden with humidity and carbonic acid than exist in our day. But, whatever may have been the geological conditions affecting the origin of coal, we may regard the deposits of that mineral as vast magazines of power stored up at periods immeasurably distant for our use. The principle of conservation of force and the relationship now established between heat and motion enable us to trace back the effects which we now derive from coal to equivalent agencies exercised at the periods of its formation. The philosophical mind of George Stevenson, unaided by theoretical knowledge, rightly saw that coal was the embodiment of power originally derived from the sun. That small pencil of solar radiation which is arrested by our planet, and which constitutes less than the 2,000-millionth part of the total energy sent forth from the sun, must be regarded as the power which enabled the plants of the carboniferous period to wrest the carbon they required from the oxygen with which it was combined, and eventually to deposit it as the solid material of coal. In our day, the reunion of that carbon with oxygen restores the energy expended in the former process, and thus we are enabled to utilize the power originally derived from the luminous centre of our planetary system. But the agency of the sun in originating coal does not stop at this point. In every period of geological history the waters of the ocean have been lifted by the action of the sun and precipitated in rain upon the earth. This has given rise to all those sedimentary actions by which mineral substances have been collected at particular localities, and there deposited in a stratified form with a protecting cover to preserve them for future use.

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* Cited from the "*Weekly Review.*"

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IS COAL THE MOST ECONOMIC HEAT POWER?

The causes which render the application of heat so uneconomic in the steam-engine have been brought to light by the discovery of the dynamical theory of heat; and it now remains for mechanicians, guided by the light they have thus received, to devise improved practical methods of converting the heat of combustion into available power. Engines in which the motive power is excited by the communication of heat to fluids already existing in the aeriform condition, as in those of Sterling, Ericsson, and Siemens, promise to afford results greatly superior to those obtained from the steam-engine. They are all based upon the principle of employing fuel to generate sensible heat, to the exclusion of latent heat, which is only another name for heat which has taken the form of unprofitable motion among the particles of fluid to which it is applied. They also embrace what is called the regenerative principle—a term which has, with reason, been objected to, as implying a restoration of expended heat. The so-called "regenerator" is a contrivance for arresting unutilized heat rejected by the engine, and causing it to operate in aid and consequent reduction of fuel. It is a common observation that before coal is exhausted some other motive agent will be discovered to take its place, and electricity is generally cited as the coming power. Electricity, like heat, may be converted into motion, and both theory and practice have demonstrated that its mechanical application does not involve so much waste of power as takes place in a steam-engine; but, whether we use heat or electricity as a motive power, we must equally depend upon chemical affinity as the source of supply. The act of uniting to form a chemical product liberates an energy which assumes the form of heat or electricity, from either of which states it is convertible into mechanical effect. In contemplating, therefore, the application of electricity as a motive power we must bear in mind that we shall still require to effect chemical combinations, and in so doing to consume materials. But where are we to find materials so economical for this purpose as the coal we derive from the earth and the oxygen we derive from the air? The latter costs absolutely nothing; and every pound of coal which in the act of combustion enters into chemical combination renders more than 2½lbs. of oxygen available for power. We cannot look to water as a practicable source of oxygen, for there it exists in the combined state, requiring expenditure of chemical energy for its separation from hydrogen. It is in the atmosphere alone that it can be found in that free state in which we require it; and there does appear to me to be the remotest chance, in an economic point of view, of being able to dispense with the oxygen of the air as a source either of thermodynamic or electrodynamic effect. But to use this oxygen we must consume some omdizable substance, and coal is the cheapest we can procure.

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MISCELLANEOUS USES OF COAL.

I have hitherto spoken of coal only as a source of mechanical power, put it is also extensively used for the kindred purpose of relaxing those cohesive forces which resist our efforts to give new forms and conditions to solid substances. In these applications, which are generally of a metallurgical nature, the same wasteful expenditure of fuel is everywhere observable. In an ordinary furnace employed to fuse or soften any solid substances, it is the excess of the heat of combustion over that of the heated body which alone is rendered available for the purpose intended; the rest of the heat, which in many instances constitutes by far the greater proportion of the whole, is allowed to escape uselessly into the chimney. The combustion also in common furnaces is so imperfect that clouds of powdered carbon, in the form of smoke, envelope our manufacturing towns; and gases, which ought to be completely oxygenized in the fire, pass into the open air with two-thirds of their heating power undeveloped. Some remedy for this state of things, we may hope, is at hand in the gas regenerative furnaces recently introduced by Mr. Siemens. In these furnaces the rejected heat is arrested by a so-called "regenerator," as in Stirling's air engine, and is communicated to the new fuel before it enters the furnace. The fuel, however, is not solid coal, but gas previously evolved from coal. A stream of this gas raised to a high temperature by the rejected heat of combustion is admitted into the furnace, and there meets a stream of atmospheric air also raised to a high temperature by the same agency. In the combination which then ensues, the heat evolved by the combustion is superadded to the heat previously acquired by the gases. Thus, in addition to the advantage of economy, a greater intensity of heat is attained than by the combustion of unheated fuel. In fact, as the heat evolved in the furnace, or so much of it as is not communicated to the bodies exposed to its action, continually returns to augment the effect of the new fuel, there appears to be no limit to the temperature attainable except the powers of resistance in the materials of which the furnace is composed. With regard to smoke, which is at once a waste and a nuisance, having myself taken part with Dr. Richardson and Dr. Longridge in a series of experiments made in this neighbourhood in the years 1857-58, for the purpose of testing the practicability of preventing smoke in the combustion of bituminous coal in steam-engine boilers, I can state with perfect confidence that so far as the raising of steam is concerned, the production of smoke is unnecessary and inexcusable. The experiments to which I refer proved beyond a doubt that by an easy method of firing, combined with a due admission of air and a proper arrangement of fire-grate, not involving any complexity, the emission of smoke might be perfectly avoided, and that the prevention of smoke increased the economic value of the fuel and the evaporative power of the boiler. As a rule, there is more smoke evolved from the fires of steam-engines than from any others, and it is in these fires that it may be most easily prevented. But in the furnaces used for most manufacturing operations the prevention of smoke is much more difficult, and will probably not be effected until a radical change is made in the system of applying fuel for such operations. Not less wasteful and extravagant is our mode of applying coal for domestic purposes. It is computed that the consumption of coal in dwelling-houses amounts, in this country, to a ton per head per annum of the entire population; so that upwards of 29,000,000 tons are annually expended in Great Britain alone for domestic use. If any one will consider that 1lb. of coal applied to a well-constructed steam-engine boiler, evaporates 10lb. or one gallon of water, and if he will compare this effect with the insignificant quantity of water which can be boiled off in steam by 1lb. of coal consumed in an ordinary kitchen fire, he will be able to appreciate the enormous waste which takes place by the common method of burning coal for culinary purposes. The simplest arrangements to confine the heat and concentrate it upon the operation to be performed would suffice to obviate this reprehensible waste. So also in warming houses, we consume in our open fires about five times as much coal as will produce the same heating effect when burnt in a close and properly constructed stove. Without sacrificing the luxury of a visible fire, it would be easy, by attending to the principles of radiation and convection,, to render available the greater part of the heat which is now so improvidently discharged into the chimney. These are homely considerations—too much so, perhaps, for an assembly like this; but I trust that an abuse involving a useless expenditure, exceeding in amount our income-tax, and capable of being rectified by attention to scientific principles, may not be deemed unworthy of the notice of some of those whom I have the honour of addressing.

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NEW FORM OF CARBURETTED HYDROGEN.

Before dismissing the subject of coal, it may be proper to notice the recent discovery by Berthelot of a new form of carburetted hydrogen possessing twice the illuminating power of ordinary coal gas. Berthelot succeeded in procuring this gas by passing hydrogen between the carbon electrodes of a powerful battery. Dr. Odling has since shown that the same gas may be produced by mixing carbonic oxide with an equal volume of light carburetted hydrogen and exposing the mixture in a porcelain tube to an intense heat. Still more recently, Mr. Siemins has detected the same gas in the highly-heated regenerators of his furnaces, and there is now every reason to believe that the new gas will become practically available for illuminating purposes. Thus it is that discoveries which in the first instance interest the philosopher only, almost invariably initiate a rapid series of steps leading to results of great practical importance to mankind. In the course of the preceding observations I have had occasion to speak of the sun as the great source of motive power on our earth, and I must not omit to refer to recent discoveries connected with that most glorious body.

MATERIALS OF WHICH THE SUN IS MADE.

Of all the results which science has produced within the last few years, none has been more unexpected than that by which we are enabled to test the materials of which the sun is made, and prove their identity, in part at least, with those of our planet. The spectrum experiments of Bunsen and Kirchhoff have not only shown all this, but they have also corroborated previous conjectures as to the luminous envelope of the sun. I have still to advert to Mr. Nasmyth's remarkable discovery, that the bright surface of the sun is composed of an aggregation of apparently solid forms, shaped like willow-leaves or some well-known forms of Diatomaceæ, and interlacing one another in every direction. The forms are so regular in size and shape as to have led to a suggestion from one of our profoundest philosophers of their being organisms, possibly even partaking of the nature of life, but, at all events, closely connected with the heating and vivifying influences of the sun. These mysterious objects, which, since Mr. Nasymth discovered them, have been seen by other observers as well, are computed to be each not less than 1,000 miles in length and about 100 miles in breadth. The enormous chasms in the sun's photosphere, to which we apply the diminutive term "spots," exhibit the extremities of those leaf-like bodies pointing inwards, and fringing the sides of the cavern far down into the abyss. Sometimes they form a sort of rope or bridge across the chasm, and appear to adhere to one another by lateral attraction. I can imagine nothing more deserving of the scrutiny of observers than these extraordinary forms. The sympathy also which appears to exist between forces operating in the sun and magnetic forces belonging to the earth merits a continuance of that close attention which it has already received from the British Association, and of labours such as General Sabine has with so much ability and effect devoted to the elucidation of the subject. I may here notice that the most remarkable phenomenon which was seen by independent observers at two different places on the 1st of September, 1859. A sudden outburst of light, far exceeding the brightness of the sun's surface, was seen to take place, and sweep like a drifting cloud over a portion of the solar face. This was attended with magnetic disturbances of unusual intensity and with exhibitions of aurora of extraordinary brilliancy. The identical instant at which the effusion of light was observed was recorded by an abrupt and strongly marked deflection in the self-registering instruments at Kew. The phenomenon as seen was probably only part of what actually took place, for the magnetic storm in the midst of which it occurred commenced before and continued after the event. If conjecture be allowable in such a case, we may suppose that this remarkable event had some connexion with the means by which the sun's heat is renovated. It is a reasonable supposition that the sun was at that time in the act of receiving a more than usual accession of new energy; and the theory which assigns the maintenance of its power to cosmical matter plunging into it with that prodigious velocity which gravitation would impress upon it, as it approached to actual contact with the solar orb, would afford an explanation of this sudden exhibition of intensified light in harmony with the knowledge we have now attained that arrested motion is represented by equivalent heat. Teloscopic observations will probably add new facts to guide our judgment on this subject, and, taken in connexion with observations on terrestrial magnetism, may enlarge and correct our views respecting the nature of heat, light, and electricity. Much as we have yet to learn respecting these agencies, we know sufficient to infer that they cannot be transmitted from the sun to the earth except by communication from particle to particle of intervening matter. Not that I speak of particles in the sense of the atomist. Whatever our views may be of the nature of particles, we must conceive them as centres invested with surrounding forces. We have no evidence, either from our senses or otherwise, of these centres being occupied by solid cores of indivisible incompressible matter essentially distinct from force. Dr. Young has shown that even in so dense a body as water, these nuclei, if they exist at all, must be so small in relation to the intervening spaces, that 100 men distributed at equal distances over the whole surface of England would represent their relative magnitude and distance. What then must be these relative dimensions in highly rarefied matter? But why encumber our conceptions of material forces by this unnecessary imagining of a central molecule? If we retain the forces and reject the molecule, we shall still have every property we can recognize in matter by the use of our senses or by the aid of our reason. Viewed in this light, matter is not merely a thing subject to force, but is itself composed and constituted of force.

DYNAMICAL THEORY OF HEAT.

The dynamical theory of heat is probably the most important discovery of the present century. We now know that each Fahrenheit degree of temperature in a pound of water is equivalent to a weight of 772 lbs. lifted one foot high, and that these amounts of heat and power are reciprocally convertible into one another. This theory of heat, with its numerical computation, is chiefly due to the labours of Mayer and Joule, though many other names, including those of Thomson and Rankine, are deservedly associated with its development. I speak of this discovery as one of the present age because it has been established in our time; but if we search back for earlier conception of the identity of heat and motion, we shall find (as we always do in such cases) that similar ideas have been held before, though in a clouded and undemonstrated form. In the writings of Lord Bacon we find it stated that heat is to be regarded as motion, and nothing else. In dilating upon this subject, that extraordinary man shows that he had grasped the true theory of heat to the utmost extent that was compatible with the state of knowledge existing in his time. Even Aristotle seems to have entertained the idea that motion was to be considered as the foundation not only of heat, but of all manifestations of matter; and, for aught we know, still earlier thinkers may have held similar views. The science of gunnery, to which

I shall make but slight allusion on this occasion, is intimately connected with the dynamical theory of heat. When gunpowder is exploded in a cannon, the immediate effect of the affinities by which the materials of the powder are caused to enter into new combinations is to liberate a force which first appears as heat, and then takes the form of mechanical power communicated in part to the shot and in part to the products of explosion, which are also propelled from the gun. The mechanical force of the shot is reconverted into heat when the motion is arrested by striking an object, and this heat is divided between the shot and the object struck, in the proportion of the work done or damage inflicted upon each. These considerations recently led me, in conjunction with my friend Captain Noble, to determine experimentally, by the heat elicited in the shot, the loss of effect due to its crushing when fired against iron plates. Joule's law, and the known velocity of the shot, enabled us to compute the number of dynamical units of heat representing the whole mechanical power in the projectile, and by ascertaining the number of units developed in it by impact, we arrived at the power which took effect upon the shot instead of the plate. These experiments showed an enormous absorption of power to be caused by the yielding nature of the materials of which projectiles are usually formed; but further experiments are required to complete the inquiry.

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ASSIMILATING OF MEASUREMENTS.

Another subject of a social character which demands our consideration is the much-debated question of weights and measures. Whatever difference of opinion there may be as to the comparative merits of decimal and duodecimal division, there can, at all events, be none as to the importance of assimilating the systems of measurement in different countries. Science suffers by the want of uniformity, because valuable observations made in one country are in a great measure lost to another from the labours required to convert a series of quantities into new denominations. International commerce is also impeded by the same cause, which is productive of constant inconvenience and frequent mistake. It is much to be regretted that two standards of measure so nearly alike as the English yard and the French metre should not be made absolutely identical. The metric system has already been adopted by other nations besides France, and is the only one which has any chance of becoming universal. We in England, therefore, have no alter-native but to conform with France, if we desire general uniformity. The change might easily be introduced in scientific literature, and in that case it would probably extend itself by degrees among the commercial classes without much legislative pressure. Besides the advantage which would thus be gained in regard to uniformity, I am convinced that the adoption of the decimal division of the French scale would be attended with great convenience, both in science and commerce. I can speak from personal experience of the superiority of the decimal measurement in all cases where accuracy is required in mechanical construction. In the Elswick Works, as well as in some other large establishment of the same description, the inch is adopted as the unit, and all fractional parts are expressed in decimals. No difficulty has been experienced in habituating the workmen to the use of this method, and it has greatly contributed to precision of workmanship. The inch, however, is too small a unit, and it would be advantageous to substitute the metre, if general concurrence could be obtained. As to our thermometric scale, it was originally found in error; it is also most inconvenient in division, and ought at once to be abandoned in favour of the Centigrade scale. The recognition of the metric system and of the Centigrade scale by the numerous men of science composing the British Association, would be a most important step towards aflecting that universal adoption of the French standards in this country which sooner or later will inevitably take place; and the Association in its collective capacity might take the lead in this good work, by excluding in future all other standards from their published proceedings.

DISCOVERY OF SOURCES OF NILE.

The recent discovery of the source of the Nile by Captains Speke and Grant has solved a problem in geography which has been a subject of speculation from the earliest ages. It is an honour to England that this interesting discovery has been made by two of her sons; and the British Association, which is accustomed to value every addition to knowledge for its own sake, whether or not it be attended with any immediate utility, will at once appreciate the importance of the discovery and the courage and devotion by which it has been accomplished. The Royal Geological Society, under the able presidency of Sir Roderick Murchison, was chiefly instrumental in procuring the organization of the expedition which has resulted in this achievement, and the success of the Society's labours in connexion with this and other cases of African exploration shows how much good may be affected by associations for the promotion of scientific objects.

DARWIN'S AND SIR C. LYELL'S WORKS.

The science of organic life has of late years been making great and rapid strides, and it is gratifying to observe that researches both in zoology and botany are characterized in the present day by great accuracy and elaboration. Investigations patiently conducted upon true inductive principles cannot fail eventually to elicit the hidden laws which govern the animated world. Neither is there any lack of bold speculation contemporaneously with this painstaking spirit of inquiry. The remarkable work of Mr. Darwin, promulgating the doctrine of natural selection, has produced a profound sensation. The novelty of this ingenious theory, the eminence of its author, and his masterly treatment of the subject, have, perhaps, combined to excite more enthusiasm in its favor than is consistent with that dispassionate spirit which it is so necessary to preserve in the pursuit of truth. Mr. Darwin's views have not passed unchallenged, and the arguments both for and against have been urged with great vigour by the supporters and oponents of the theory. Where good reasons can be shown on both sides of a question the truth is generally to be found between the two extremes. In the present instance we may without difficulty suppose it to have been part of the great scheme of creation that natural selection should be permitted to determine variations amounting even to specific differences where those differences were matters of degree; but when natural selection is adduced as a cause adequate to explain the production of a new organ not provided for in original creation, the hypothesis must appear to common apprehensions to be pushed beyond the limits of reasonable conjecture. The Darwinian theory, when fully enunciated, founds the pedigree of living nature upon the most elementary form of vitalized matter. One step further would carry us back without greater violence to probability, to inorganic rudiments, and then we should be called upon to recognize in ourselves, and in the exquisite elaborations of the animal and vegetable kingdoms, the ultimate results of mere material forces left free to follow their own unguided tendencies. Surely our minds would in that case be more oppressed with a sense of the miraculous than they now are in attributing the wondrous things around us to the creative hand of a great presiding Intelligence. The evidences bearing upon the antiquity of man have been recently produced in a collected and most logically-treated form by Sir Charles Lyell. It seems no longer possible to doubt that the human race has existed on the earth in a barbarian state for a period far exceeding the limit of historical record; but, notwithstanding this great antiquity, the proofs still remain unaltered that man is the latest as well as the noblest work of God. I will not run the risk of wearying this assembly by extending my remarks to other branches of science. In conclusion I will express a hope that when the time again comes round to receive the British Association in this town its members will find the interval to have been as fruitful as the corresponding period on which we now look back. The tendency of progress is to quicken progress, because every acquisition in science is so much vantage ground for fresh attainment. We may expect, therefore, to increase our speed as we struggle forward; but however high we climb in the pursuit of knowledge we shall still see heights above us, and the more we extend our view the more conscious we shall be of the immensity which lies beyond."

Chemical Science.

We give the President's address in full:—"Before the Section enters upon the business for which it meets—that is to say, the consideration of Papers and Reports upon Special Branches of Chemistry and the Chemical Arts—it may not be unacceptable to cast a brief and cursory glance at some few topics illustrative of the tendencies of chemical science during the last few years and of its applications to some of the manufacturing arts. One of the most remarkable features of the progress of our science is the rapid rate at which materials have been accumulating by the labours of chemists in the so-called organic department of the science. The study of the transformation of organic bodies leads to the discovery of new acids, new bases, new alcohols, new ethers, and at a constantly increasing rate which is truly wonderful. Some of these new substances are found to possess properties which can at once be applied to practical manufacturing processes, such as dyeing,&c.; but the greater number of them remain in our laboratories, and museums, and text-books, and serve to teach us new instances of the combining forces of matter. The influence of this rapid growth of materials upon our knowledge of principles and laws of combination, which constitute the science of chemistry, has been simultaneous with the discoveries of the materials themselves; and the material and intellectual progress of organic chemistry have gone on so regularly hand in hand that it is impossible to say which has done most in helping the other. It is, accordingly, observed that the science has been simplified by every important addition to her materials; instead of isolated unmeaning substances, with formulæ so complex and unintelligible as to be troublesome to chemists and truly distressing to learners, we have now definite and intelligible families of bodies, of which the members are most harmoniously united together by some law of composition, and whose connection with neighbouring families is similarly clear and satisfactory. New discoveries are constantly coming in to fill up the gaps which still disfigure our growing system. In mineral, or inorganic chemistry, there is not the same scope for discovering at present, inasmuch as the elements which belong to it do not combine in those numerous proportions which occur among the chief elements of organic bodies. But yet, mineral chemistry has not been standing still: for even the heavy metals most remote in their properties from those volatile and unstable substances of organic chemistry, have been got in many instances to combine with them; and the organo-metallic bodies thus formed have not only proved most valuable and powerful agents of decomposition, but they have served as a connecting link between the two branches of chemical science. A system of classification of elements is now coming into use, in which the heavy metals arrange themselves harmoniously with the elements of organic bodies, and in accordance with the principles which were discovered by a study of organic compounds. It is now many years since the attention of chemists was directed by a French professor to some inconsistencies which had crept into our system of atomic weights. Gerhardt showed that the principles which were adopted in fixing the atomic weight of elementary bodies generally required us to adopt for oxygen, carbon, and sulphur numbers twice as great as those generally in use for those elements. The logic of his arguments was unanswerable; and yet Gerhardt's conclusions gained but few adherents. It is to be observed that for some years Gerhardt represented chemical reactions by so-called synoptic formulæ, which took no account of the existence of organic radicles. These synoptic formulæ represent in the simplest terms the result of a chemical reaction; but they give no physical image of the progress by which the reaction is brought about. The introduction, in this country, of the water-type in connection with poly-atomic as well as mon-atomic radicles, was found to satisfy the requirements of the synoptic formulæ. Gerhardt was the first to adopt them from us He gave, in his admirable 'Traité de Chimie Organique,' a system of organic chemistry on that plan; and his book has been of immense service to the development of our science. The extension of these principles to mineral chemistry had been commenced in the cases of the commonest acids and bases; but their general introduction met with difficulties, and sometimes seemed wanting to their complete success. I must now travel southward for a short time, and ask you to accompany me to the sunny land of glorious memories, and to its southern dependency—the Island of Sicily. It was reserved for Professor Cannizzaro, of the University of Palermo, to show us how the remainder of the knot could be untied. He argued, upon physical as well as chemical grounds, that the atomic weight of many metals ought to be doubled, as well as those of oxygen, sulphur, and carbon. His conclusion is confirmed by the constitution of those organo-metallic bodies which I mentioned just now; and it certainly does seem to supply what was still wanting for the non-metallic elements to the heavy metals themselves. The elements are now arranged into two principal groups:—1st. Those of which each atom combines with an uneven number of atoms of chlorine or hydrogen. 2nd. Those of which each atom combines with an even number of atoms of chlorine or hydrogen. Like every classification founded upon nature, this one draws no absolute line, as some elements belong to both classes. The first group includes the mon-atomic elements of the chlorine family, the tri-atomic elements of the nitrogen family, hydrogen and the alkali-metals, silver and gold—in all about eighteen elements. The usual atomic weights of these are retained. The usual atomic weights of all the other elements, biatomic, tetratomic &c., are doubled. The second group includes the oxygen family—carbon, silicon, and the alkaline earths; the metals, zinc, iron, copper, lead, &c. Every step in our theoretical development of chemistry has served to consolidate and extend the atomic theory; but it is interesting to observe that the retention of that theory has involved the necessity of deprving it of the absolute character which it at first possessed. Organic compounds were long ago discovered, containing atoms of carbon, hydrogen and oxygen, in proportions far from simple; and the atomic theory must have been abandoned but for the discovery that the atomic, or rather molecular weights of these compounds correspond invariably to entire numbers of the elementary atoms. We now use the term molecule for those groups which hold together during a variety of transforformations, but which can be resolved into simpler constituents: whilst we receive the word atom for those particles which we cannot break up, and which there is no reason for believing that we ever shall break up. Amongst the most brilliant extensions of our means of observation have been the researches in spectrum analysis. The application of these beautiful methods to the investigation of minerals has already led to the discovery of three volatile metals which had previously escaped observation, whilst its extension to the investigation of the light which reaches our planet from the heavenly bodies has led to the recognition, in several of them, of elements identical, in this respect at least, with some of our elements in this earth. An eminent French chemist has recently taken occasion, in reporting the results of some researches on the new metal 'Thallium,' to volunteer insinuations against Mr. Crooke's claim to that discovery. M. Dumas considers it corroborative of his views that Mr. Crooke did not refer the consideration of his claims, on the first opportunity, to a jury of gentlemen, formed for examining products of manufacturing industry at the National Exhibition of 1862. I have felt it my duty to allude publicly to this proceeding, because it occurred in a report of a commission of the French Academy, published by the order of that distinguished body. Before proceeding from the scientific and intellectual progress of chemistry, I must beg leave to refer briefly to the educational effects of the progress. Little, indeed, would our conquests over nature avail us if they are only known to the systematic cultivators of science and only used by them; and, unless the popular dissemination of knowledge keeps pace with its extension, the chief fruits of that extension will be lost. It would be unjust to deny that some important steps have been taken of late years by various governing bodies in this country towards giving to experimental science a position in national education; but these steps are only the beginning of a reform in education which must go much farther in order to be effectual. In illustration of what has been done, I may mention the admission of chemistry and physics into the list of subjects of examination for various Government appointments, civil and military; but the small value which the framers of the schemes placed upon these sciences, compared to mathematics, is but too plainly shown by the small number of marks which they assign to the utmost recognized proficiency in them; so that the effect of the recognition is tantamount to saying, 'We can't help acknowledging these sciences, but we want to encourage the study of them as little as possible.' The medical corporation, who influence the studies of the rising generation of practitioners by their examinations, have not only recognized the necessity of a thorough knowledge of chemistry, but many of them require the knowledge to be acquired in the lecture-room, but partly also in the laboratory. The University of London is expressly to be noticed for the beneficial influence which it has exerted in this direction in its medical examinations; but more particularly for the institution of new degrees of Bachelor and Doctor of Science, which acknowledges, for the first time in this country, the physical and natural sciences as entitled to equal recognition with classical and mathematical studies for purposes of general education. These influences have no doubt contributed materially to the introduction of chemical instruction, and even of practical chemistry, into junior schools, which has been going on so extensively of late years. It is, however, consolatory to observe that a more powerful influence than any of these is at work—viz., the popular appreciation of its real value, gradually raising physical science to the prominent place in national education which it is destined to occupy. If education is intended to prepare young people for a life of usefulness, in which their various faculties may be employed to the benefit of their fellow-men, and consequently to their own, there can be no doubt of the value of teaching them to observe, to recollect, to arrange the phenomena of the physical world, and to apply the knowledge and skill thus acquired to practical purposes. No phenomena that can be brought within the observation of everybody by inexpensive experiments are so simple in their nature, no reasonings, more definite and tangible, or more easily controlled by special observations than those of chemistry; and the science affords probably scope for more thorough training of the various faculties of the mind than can be supplied to schools by any other means. Among the chemical arts much has been doing; but, as usual, in a quite undemonstrative way. First and foremost among improvements I must mention the introduction into one manufacture after another of those admirable furnaces invented by Mr. Siemens, and generally known as regenerative furnaces. Whether we consider them from the point of view of the economy of fuel, or whether as affording the means of attaining temperatures beyond the range of other furnaces, there can be no doubt of the immense value of this invention.

Heat is the great source of power in almost all our dealings with inorganic matter; and I have not the slightest doubt that the power over heat given by these regenerative furnaces will revolutionize many a chemical art. The manufacture of iron, and its subsequent treatment for the removal of impurities, has been of late years the subject of many experiments. Various plans have been proposed for avoiding the injurious effects of the mineral impurities of our coal, by using gas for the reduction of the iron ores. In this country, however, the manufacture of cast iron is carried on in such vast quantities that changes in the processes must meet with great resistance. The laborious and expensive process of puddling, hitherto adopted for burning out the carbon from cast iron, is being gradually superseded by one or other of the following:—either by treating the molten pigs with oxide of iron until the carbon is removed as carbonic oxide; or by Bessemer's process of blowing air through the molten coast iron. In either case it is desirable to add some carbon to the malleable iron in order to render it more fusible; and for this purpose the best material is the manganiferous carburet of iron, known by the name of 'Spiegeleisen,' of which enough is used to make a low steel of about half per cent. of carbon. One of the most interesting novelties in metallurgy is the manufacture of aluminum, now carried on chiefly for the sake of its alloy with copper, by the distinguished gentleman who holds the office of Mayor of Newcastle. The mechanical properties of this so-called aluminum bronze give it great value; and it seems likely to find much favour for its appearance. Mr. Bell has also rendered no small service to science by collecting and preparing a large quantity of that wonderful new metal, thallium. Among alloys, a variety of brass containing a small quantity of iron has recently attracted considerable attention. The alloy is by no means new, though hitherto known but to few persons. It combines tenacity with elasticity to a remarkable degree, and can be easily forged. Most of the members of the Section are probably aware of the admirable series of agricultural experiments which have been proceeding for the last twenty years under the directions of Mr. Lawes of Rothansted; yet many are probably unaware of the vast importance of the results already established by those experiments Few things are perhaps more difficult than to conduct scientific experiments in any practical art like farming, to find how the resources which science discovers can be profitably turned to account, or how the defects which theory points out in ordinary working processes can be profitably remedied. It is almost proverbial that the greater number of persons who attempt the introduction on their farms of plans suggested by abstract science, succeed only in finding how to lose money. It does indeed require a rare combination of enthusiasm with caution, of knowledge of theory with practical experience of the conditions of ordinary working, to carry such experiments to a definite and useful issue. Such rare combinations of qualities have existed in Mr Lawes; and, when we recollect that, by associating Dr. Gilbert with his labours, he obtained the co-operation of an able and accomplished chemist, we have no longer reason to wonder that the results of twenty years' continuous experiment, conducted on an ample scale, with the most scrupulous care and systematic order, should have led to the establishment of results so numerous and important as to secure for Mr. Lawes the highest rank among the founders of scientific agriculture. In speaking of the chemistry of agriculture, I cannot omit alluding to the writings of Liebig, which have rendered such important services by bringing vividly before the English agriculturists what was known of the chemistry of farming, and several ingenious and suggestive theories relating to practical agriculture. In the introduction to the last German edition of his Agricultural Chemistry, Liebig refers in terms of studied disrespect to the investigation of Mr. Lawes, and, while misquoting a paragraph in one of Mr. Lawes' publications, endeavours to convey the impression that that gentleman was unacquainted with the correct use of the term 'mineral,' and had misunderstood Liebig's mineral theory; which he is generally considered to have disproved. I mention this circumstance with pain, and have no doubt that all who value Liebig's truly important scientific labours will regret it as much as I do. Another practical question which science has latterly brought prominently before the attention of the public is that of the utilization of the drainage of towns. It is estimated that the quantity of nourishment for plants wasted in London alone in this form is worth about a million sterling per annum; but this valuable material is contained in so large a quantity of water that no plan has come into working for separating it out profitably for use. Some persons are of opinion that the sewage might with advantage be conveyed through pipes for use in the fields, especially on meadow-land, to which it is most easily applicable. Baron Liebig has written a letter on the subject, which was forwarded by Alderman Mechi to the *Journal of the Society* *of Arts*, containing a proposal to mix the liquid with superphosphate of lime before distributing it, by which he considers that the value of the constituent already contained in the liquid will be practically increased. It is, however, not likely that the opinion of a chemist will decide the authorities to adopt an experimental scheme of the kind, as it is really rather an engineering and commercial than a chemical question. The practical test of value commercially is how much an article will fetch; and the data of this kind before us do not lead to the anticipation of a profit at all approaching to what theory suggests from the sale of this refuse. At Croydon (a town of about 18,000 inhabitants) it appears that the sewage is sold for something over a thousand pounds per annum. Another refuse material which has already come to possess great value is coal tar. Not only is our chief supply of ammonia, the food of plants, derived from that source, but those brilliant and varied colours, which are now so much in use for dyeing silk, also owe their origin indirectly to the same source. There is, perhaps, no more striking instance of the benefits which ultimately arise even to the manufacturing arts, from every complete investigation of chemical substances than is afforded by those beautiful dyes which have sprung up to-day from aniline, which yesterday was a chemical novelty in the hands of a first rate investigator."

NATURAL HISTORY.

THIRD REPORT OF THE SCIENTIFIC CURATOR.

Since the annual meeting of the Society on May 19th, 1863, from which this report dates, the annual report for the last season has been issued to the members. Last year the published list of members was very inaccurate, and special care has been taken to remedy this defect. The list of donations to the museum during the past year has been prepared very carefully, and the proper scientific name of each specimen has been recorded.

The co-operation of members of the Society is requested, in the endeavour to make the annual reports in future as reliable as possible. The compiler will be thankful for the correction of any error, or for the rectification of any omission—more especially in the list of members.

In consideration of Sir W. Logan's valuable donation to the Society of marine shells, sea urchins, crustaceans, corallines, &c., (collected mostly in the Gulf of the St. Lawrence, by the officers of the Geological Survey,) it was voted by the council that it be part of my duty to distribute the duplicate specimens in this series, with a view partly of rendering the cases containing them, available for other purposes. I have therefore selected, labelled, and packed up five sets which have been sent (at the expense of the Geol. Survey) to the following Institutions :

University College,	Toronto.
Queen's College,	Kingston.
McGill College,	Montreal.
Museum of the Literary and Historical Society,	Quebec.
Laval University	Quebec.

Letters acknowledging the receipt of these, and containing votes of thanks, have been duly received. The remainder of the duplicates, belonging to the Geol. Survey, have been put away.

The Society's collection of shells and bryozoa has been thoroughly arranged and named. On the left hand side of the gallery all the North American species have been grouped in twelve cases. The general collection occupies the whole of the right hand side of the gallery, and one large case at the end of the gallery has been devoted to such large shells as could not conveniently be classified in the side cases.

The Society's collections of foreign shells now fill fourteen cases. Printed labels have been procured, explanatory of the contents of each case.

The corals, sponges, crustaceans, and in fact all the invertebrata except the insects, have been classified and arranged in one large case at the south end of the gallery. The specimens are partly named, but the labelling of the specimens in this case is not quite finished. I have endeavoured to procure from friends such specimens as were wanting to complete the above mentioned series, with what success the printed lists of donations to the museum will show.

In the lower room the whole of the Society's collection of birds has been re-arranged, and large printed labels have been affixed to each case descriptive of its contents. This collection has been carefully gone over, and all those species that were previously unnamed, have been properly labelled.

The foreign birds have been partly named. I have written to England for printed labels to affix to each species in our collection of British birds and their eggs. The birds' eggs belonging to the Society have been thoroughly arranged and named, and, in many cases, new specimens procured. It is much to be desired that a proper cabinet be voted for their reception, as exposure to light materially injures the specimens by causing their colours to fade.

The mammalia have also been carefully gone through, and the whole collection properly named and labelled. Two large cases of Canadian fishes have been prepared by Mr. Hunter; these have been named, and proper printed labels have been affixed to each species.

Dr. Hunt has promised to render his valuable assistance in naming our collection of minerals.

Sir W. Logan has kindly promised to give us a series of the most typical Canadian rocks, minerals, and fossils, some time during the ensuing winter.

The council of the Society have voted that a large case be made to contain all the mammalia, including those specimens on the floor in the centre of the room, many of which sadly want cases; also that a proper insect cabinet be procured, large enough to contain the whole of the Society's collection of insects.

Much remains to be done; the collection of insects as yet is untouched, as also are the reptiles. Many of the foreign birds are still unnamed, and most of the foreign fishes. The fossils, anatomical preparations, and the whole historical, archæological and miscellaneous collections of the Society are still in a state of chaotic confusion.

It is to be hoped, however, that in time the museum may be made more worthy of the city and indeed of the whole province, both as a place of reference for special students, and as a medium for imparting general information.

J. F. Whiteaves, F.G.S., &c.,
Scientific Curator and Recording Secretary.

DEATH OF PROFESSOR EMMONS.

"Died, at Brunswick, North Carolina, on the 1st October last, in the 65th year of his age, Ebenezer Emmons, M.D., late of the city of Albany.

"This announcement will fill many hearts with sadness. Dr. Emmons was long a resident of this city, and by long holding professorships in two institutions, viz: the Albany Medical College and Williams College, at Williamstown, Massachusetts, he has become intimately acquainted with great numbers of young men, then students, but now engaged in professional and other avocations. Dr. Emmons was an early graduate of Williams College, and commenced life as a physician. His tastes, however, almost immediately led him into the domain of science, more especially in that department known as Natural History. He was early elected professor of Natural History in Williams College. So high a reputation had he acquired, that when the Geological Survey of this State was undertaken, he was selected as one to whom in part its Geological, and wholly its Agricultural department would be the most safely confided. How well and thoroughly his work was done is attested by his valuable reports on Geology and Agriculture, which have forever connected his name with the growth of Science and the development of the physical resources of this State. He was also for a long time the editor of an agricultural journal, and the author of a valuable work on American Geology. For the last few years he has been engaged in a Geological survey of North Carolina, and was thus engaged at the time of his death.

"Dr. Emmons exhibits a life long devotion to Science. Patient, persevering, cautious in his facts, rigid in his deductions, he has always carried into all the departments of Science he has investigated a strong common sense, which has essentially influenced his conclusions. Among the scientific men of this country he held a high rank. Although disagreeing with many of them on some important points in Geology, especially the Taconic system, of which he was the originator and supporter, yet more recent investigations have tended to show his sagacity and correctness. His name will long live in the scientific annals of this country.—Albany Journal, Nov. 6, 1863.

DEATH OF PROF. EILHARD MITSCHERLICH.

Prof. Mitscherlich has recently died at Berlin at the age of sixty-nine. He had long been known as one of the ablest philosophical chemists of the day, and the estimation in which he was held was exemplified by the numbers who attended his classes in the University of Berlin, and the Friederich-Wilhelm's-Institut in in that city. The mere titles of his writings would occupy nearly two columns of this journal; they embrace a wide range in chemical science, and may be found in the publications of the

Academy of Sciences of Berlin, of which he was a member, and in German periodicals. Besides these, he was the author of a 'Lehrbuch der Chemie,' in two volumes, which has passed through two editions, and has been translated into French. Dr. Mitscherlich was elected a Foreign Member of the Royal Society in 1828; and in 1829 one of the Royal Medals was awarded to him for his "Discoveries relating to the Laws of Crystalization and the properties of Crystals." It is, perhaps, by his researches into the phenomena of dimorphism that he will be best remembered.—Athenæum, No. 1876, p. 470.

AMERICAN TEA PLANT.

A newspaper announcement states that the Tea Plant has been discovered by a Chinaman (or, as some say, by an Englishman formerly engaged in the tea culture in Assam), in the United States, "covering a large area of land in the central counties of Pennsylvania;" and that tea of excellent quality and various sorts, green and black, has been made for the market by a company organized for the purpose. We are told that the agent of this company exhibits in this connexion a drawing, which is recognized as representing a genuine Tea-Plant.

A specimen of the prepared tea has been shown to us; by which we recognize that this American Tea-Plant is the well known *Ceanothus Americanus*, the *New Jersey Tea*, the leaves of which were used for this purpose at the beginning of the American revolution. Some one has remarked that the substituted beverage must have tried the patriotism of our great-grandmothers; but others report more favourably of its qualities.—PROF. GRAY, in *Silliman's Journal.*

A Natural History Association has just been established in Ottawa, which we hope will prove active and successful in advancing the interests of Natural History in connection with that interesting region. The following extract appears in one of the Ottawa, newspapers:

The public meeting, called for the purpose of organizing a Natural History Association, met, according to adjournment, at the Mechanics' Institute, on Saturday evening last; and after adopting a constitution and code of by-laws, proceeded to the selection of officers, when the following gentlemen were elected for the current year:—President, A. Billings, jr., Esq.; 1st Vice-President, N. B. Webster, Esq., A.M.; 2nd Vice-President, George Hay, Esq., Secretary, Thomas Austin, Esq.; Curator and Librarian, E. Vancortland, Esq., M.D.; Committee of Management: J. Thorburn, Esq., A. M.; Duncan Thompson, Esq., and Thomas Daniel, Esq.

CORRESPONDENCE.

Description of Elephantine Molars in the Museum of the University. By Prof. A. WINCHELL.

(In a letter to one of the Editors of this Journal.)

ANN ARBOR, Mich., Aug., 1863.

MY DEAR SIR,

Your favour of 25th June was duly received, and I thank you for its various items of information. Relative to the remains of fossil elephants in the museum of the University, I regret to say that you have been misinformed. We have a cast of an entire lower jaw and a tusk of a mastodon from near St. Thomas, C. W., obtained from Thomas Barret, of Niagara Falls, and not unlikely you are in possession of similar casts. Probably this jaw has given rise to the report of which you speak. Of elephant remains the museum contains only three molars. As a description of these may furnish some items of desirable information for you, I have delayed somewhat my reply to your letter with the view of obtaining time to make such observations as might be necessary for a description of them.

1. The first is a cast of a left upper molar received by me from Prof. Tuomey, of Alabama, who had the cast executed from a specimen found in that state.

The anterior extremity of the tooth seems to have been broken off, and I think it is proper to allow one inch (including two plates) for this loss. The alveolar portion of the tooth is furnished with several fang-like prolongations, the anterior one of which reaches a length of nearly two inches. The outer side of the tooth exhibits a curvature having a radius of about eight inches; the inner side is nearly straight. The crown presents a slight convexity longitudinally, and is flat transversely. The plates extend with slight, irregular undulations, continuously from side to side. The posterior ones—especially those behind the grinding surface—are somewhat curved in their prolongation from the crown to the roots of the tooth.

2. A well-preserved left lower molar from a peat bed in Jackson county, Michigan.

This tooth presents a marked longitudinal convexity on the outer side, while the inner side, in the vicinity of the crown, is nearly straight to the posterior third, when it becomes somewhat concave internally. The grinding surface is deeply concave—the middle being depressed nearly an inch below the extremities, and about one third of an inch below the adjacent sides. The grinding surface, moreover, is twisted so that its plane, near the posterior extremity, makes an angle of about 15° with the same plane near the anterior extremity, the crown being more turned outwards posteriorly. The five posterior plates still present traces of the digitations; in the third from the extremity are five equidistant circular digitations. The posterior plate, as it penetrates the body of the tooth, curves backwards and then forwards, presenting a posterior convexity. The hinder plates are placed at right angles with the crown-axis, but in proceeding forwards the outer ends are most rapidly advanced, so that near the middle of the crown the plates make an angle of only about 80° with the crown-axis, and the 10th plate is duplicated in its outer half to fill up the enlarged space in the outer curvature. When the tooth rests on its crown and is viewed from the side, the profile is nearly an equilateral right-angled triangle, truncated two fifths of the way down from the apex. The hypothenuse, or anterior slope of the alveolar portion of the tooth is furnished with six short fangs produced by deep folds of the dentine. The truncated portion, viewed from the side opposite the crown appears to be an irregularly long cup or crater of dentine, covered externally by cement, and filled with the same substance to within two-thirds of an inch of the rim. The cement of this tooth is nearly black, and is about .075 of an inch thick on the exterior; the dentine is light-coloured immediately beneath, and quite white in its deeper substance. The enamel, which projects in the plates, above both the cement and the dentine, retains a fine chalcedonic colour and lustre.

3. Cast of a left lower molar, found near Toronto, C. W., and obtained from Thomas Barret, of Niagara Falls, C. W.

This tooth is curved on both sides, with the convexity turned outwards. The grinding surface is strongly concave both longitudinally and transversely. One strong fang on the anterior portion of the tooth seems to have been removed. Posteriorly the apparent removal of the deeper alveolar portion has exposed ten of the plates.

The following table exhibits the dimensions and other precise characters of the three teeth:

	No. 1. Alabama	No. 2. Michigan	No. 3. C. W.
Total length	11 in*	16.25 in.	7 in.
Length of grinding surface	9 "	10.50 "	5 "
Projection posteriorly beyond the grinding surface	1.25 in.	0.75. "	2 "
Whole number of plates	28 "	19 "	19 "
Number of plates on the grinding surface	21† "	19 "	15 "
Mean distance of plates on grinding surface	0.43 "	0 55 "	0.33 in.
Greatest width of crown	4 "	3.64 "	2.50 "
Average thickness of plates	0.20 "	0.33 "	0.20 "
Greatest height when resting on crown	8.50 "	6.50 "	4.75 "
Ratio of length and breadth of tooth	2.75 "	3.09 "	2.80 "

*Allowing one inch for apparent loss.

† Allowing two plates for portion lost.

The foregoing examination of three elephantine molars in my possession shows that they probably agree sufficiently well to belong to one species. The mean distance of the plates conforms also with the data which you have given in the *Canadian Naturalist*, and seems, as you conclude to point to a distinction between *Elephas primigenius* and the remains commonly found in the United States and Canada West. The Michigan tooth presents the most marked peculiarities, and these may be enumerated as follows:

1. A greater mean distance of the plates.
2. The oblique position of the middle and anterior plates.
3. A remarkable twisting of the grinding surface.
4. A smaller relative thickness.
5: A different disposition of the dentine in the deeper or alveolar portion of the tooth, especially as contrasted with the Canadian molar.

Very truly yours,

A. Winchell.

E. Billings, F. G. S.
Palæontologist, &c., &c.,
Montreal, C. E.

THE

CANADIAN

NATURALIST AND GEOLOGIST.

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Art. XXVIII.—*A list of Animals dredged near Caribou Island, Southern Labrador, during July and August*, 1860; by A. S. Packard, Jr.

The following results were collected during a stay of fifty days, with a party of six others, left by the Williams College (Mass.) Expedition to Greenland, in the summer of 1860.

Caribou Island is situated in the extreme N. E. corner of the Gulf of St. Lawrence, at the entrance of the straits of Belle Isle in lat. 51°.25, long. 57°.39. It is composed of sienitic rocks, and is the largest of many small islets which line the coast of Labrador between the Mecatinas and Bradore. Like many others, this island is situated directly opposite the mouth of a long narrow bay, or reach, two or three miles in extent, which receives a shallow impetuous stream. Salmon Bay, thus protected from the heavy swell of the Gulf, by the high cliffs of Caribou island, affords, with its deep muddy bottom, good anchorage, and a comparatively quiet harbor for the fishing vessels which yearly frequent it. It is connected on the west by a narrow ship channel with another exposed bay which receives Esquimaux River. On the east side, between the island and the mainland, is a narrow passage closed to navigation by a sand bar, where the fishermen draw their nets for capelin, lance fish, and young cod for bait. As the water deepens towards the gulf, the sand grows coarser, till farther out, where the strong current, sweeping down the Straits, carries off the fine sediment, the bottom is most curiously paved with polished and clean "cobble stones." This barren bottom is scattered over with patches of Desmarestia, Ptilota, and Agarum, which give shelter to Hyas, Chiton, Cynthia, and a few Echini. Three or four miles further out into the Straits, a long narrow ledge forms the "Bank," whose crown rises to within eighteen fathoms of the surface, and it is here that the Astrophyton abounds most. On this bank the Ptilota elegans and the Nullipora polymorpha were the only plants observed. Indeed I was struck with the poverty of this locality in sea weeds, compared with the mouth of the St. Lawrence river, as catalogued in a previous number of this journal.

The rocky shores exposed to surf from the Gulf did not seem to harbor any animal life, but a narrow, interrupted belt of sand and mud flats in Salmon Bay, with patches of *Zostera marina*, about six inches in length, exhibited a feeble assemblage of littoral animals compared with that of Maine, even. In the higher levels of the zone, whose whole extent was only six feet vertically, were *Littorina rudis*, *Rissoa minuta*, *Balanus balanoides* and *Jaera copiosa;* and below, *Mya arenaria*, *Macoma fusca*, *Mytilus edulis*, *Littorina littoralis*, *Tectura testudinalis*, and *Nereis*. In the pools on the flats, myriads of *Mysis* and *Crangon* occurred with Platessa and Cottus; under the rocks and seaweed, *Gammarus mutatus*, *Cancer borealis*, and occasionally *Homarus Americanus;* and on the fuci *Laomedea*, with *Dynamena pumila.*

The entire absence of any specimens of *Purpura lapillus* was inexplicable, though I searched for that shell. So also I did not find any species of *Idotaea*, though it is found at Anticosti, and I took it from seaweed floating a few miles off Cape Ray, Newfoundland. There were also no Planarians or Nemerteans observed between tide marks.

Another belt, extending a fathom or two below low water mark, was characterized by the three species of *Asterias*, *Solaster pappoas*, *Echinus*, *Echinarachnius*, *Pecten tenuicostatus*, *Mesodesma Jauresii*, *Margarita helicina*, *Buccinum undatum*, *Pycnogonids*, *Cuma*, *Hyas aranea*, *Desmarestia* with *Spirorbis*, *Eupagurus*, two species, and *Agarum* with eggs of *Nudibranchs;* but no forests of *Laminaria* such as those in Maine, occurred around Caribou Island.

The muddy and sandy bottom of Salmon Bay in 15 to 20 fathoms was characterized by *Ophoiglypha nodosa*, *Pentacta calcigera*, *Nucula tenuis* and *expansa*, *Leda buccata*, *Thyasira Gouldii*, *Car-*

dium islandicum and *pinnulatum*, *Serripes Grœnlandicus*, *Macoma proxima*, *Turritella reticulata* and *erosa*, *Aporrhais occidentalis*, and the different species of *Bela*, with *Pectinaria Eschrichtii* and *Onuphis Eschrichtii*. These all occurred in the greatest abundance.

So also out on the Bank in fifty fathoms did the following, which are mentioned here at the risk of repetition, since they are of special interest in connection with the patches of Drift fossils found up and down the St. Lawrence, and in New England.

Yealia crassicornis ?
Sertularia, &c.
Astrophyton eucnemis.
Ophiacantha spinulosa.
Eschara, Cellepora, and the species of Lepralia.
Hippothoa, Stomatopora &c.,
Anomia, two species.
Hypothyris psittacea.
Pecten islandicus.
Cardita borealis.
Astarte, two species.
Modiolaria decussata.
M. corrugata.
Glycimeris siliqua.
Mya uddevallensis.
Diadora noachina.
Margarita cinerea.
Admete viridula.
Trichotropis borealis.
Fusus tornatus.
Trophon scalariforme.

with *Spirorbis cancellata* and S. *vitrea*, *Vermilia serrula*, *Hippolyte spini*, *Chionoecetes opilio*. Dredging was carried on for about six weeks; from the middle of July to the last of August, during a season that proved to be the most boisterous and foggy that the inhabitants had experienced for twenty years.

Dr. William Stimpson has kindly identified the annelides and crustacea, so far as their state of preservation would allow, and given me aid in the determination of several other forms. I am under obligations to Theodore Lyman, Esq., Museum of Comparative Zoology, Cambridge, for naming the Ophiurians, and to Dr. Dawson, for identifying several species of Lepralia. I subjoin the names of some Foraminifera sent him in sand, &c., which he has furnished me.

Polystomella umbilicatula, *Truncatulina lobata.*

Miliolina seminulum (some very large and complex).

Biloculina ringens, *Entosolenia globosa* (var. *costata*).

Polymorphina lactea, *Nonionina umbilicatula*, *Textularia variabilis*, *Nodosaria ?* *Spiroloculina ?*

POLYPI.

Tealia crassicornis ? Gosse. On stones 15–50 feet.

ACALEPHÆ.

Halecium muricatum Johnst. Frequent on the Bank. Its occurrence on our coast has not before been noticed.

Laomedea gelatinosa Johnst.? Frequent on fuci in the lower levels of the littoral zone. By no means so common as in Maine.

Dynamena pumila Lam. Occurs with the preceding.

Sertularia rosacea Johnst. Very abundant in 50 feet on the Bank.

Sertularia tricuspidata Alder. Exactly agrees with Alder's figure and description in the Annals Nat. Hist. Abundant on the Bank upon *S. rosacea.*

Campanularia verticillata Lam. Several specimens dredged on the Bank.

Lafoea ramosa Lam. Abundant,occurring upright and branching out from a common stout stalk, or creeping upon *S. rosacea* in 50 feet on the Bank.

Clava multicornis Pallas. On shells.

Hydractinia polyclina Ag. On an ascidian in 15 feet Salmon Bay.

Aurelia flavidula Per. and LeS. The young and mature were very abundant. The young were both yellowish and purplish.

Cyanea arctica Per. and LeS. This is the common species in the Gulf and about the Banks, and is rarely seen in retired bays where A. flavidula abounds. The fishermen experience much discomfort from handling fish lines entangled in the very long tentacula of this species.

Idyia roseola Ag. This is doubtless the species so common on this coast.

ECHINODERMATA.

Astrophyton eucnemis Müll. and Trosch.

One was hauled up by a fisherman 20 miles from land in about 80 feet. They are common and very large in 18 feet on the crown of the Bank.

Ophiacantha spinulosa Müll. and Trosch. Several from the Bank.

Ophiopholis aculeata Lütken. Most abundant among nullipores in 15 feet. A few were taken in dead pectens in 2 feet. Also from the Bank in 50 feet.

Ophioglypha nodosa Lyman. This species was especially abundant on a sandy bottom in Salmon Bay in 10 feet, and ranges from low water mark to 50 feet.

Solaster papposa Forbes. Occasionally taken with the dip-net a few feet below low water mark.

Cribella oculata Forbes. Among nullipores in 15 feet.

Asterias vulgaris Stm. (Asteracanthion rubens, M. and T.) Common just below low water mark. The largest specimens from 8-10 inches across.

Asteracanthion polaris M. and T. Occurring with and as common as the preceding, if not more so. Often taken, especially the young in 10-15 feet.

A. n. sp? Large specimens measuring 20 inches across frequently occurred in pools at low water mark. The color in life was a light greenish hue, mottled with reddish brown.

Foxopneustes drobachiensis Ag. (E. granulatus Say.) Specimens measuring four inches across were often taken at low water mark. It extends to 50 feet, at which depth it was dredged on the Bank frequently, where the specimens were uniformly small: but after a careful study I cannot see any permanent specific differences. I cannot see that it differs at all from individuals collected during the past summer at Eastport.

A specimen in my possession from Greenland seems to be very distinct from our Labrador and Maine species. The periphery is distinctly pentagonal. The whole shell is more elevated; while the sides of the shell are not so full and rounded as in our species, the ambulacral plates are not slightly depressed, nor that area so distinctly marked as in ours. The tubercles are fewer and proportionately larger; thus in the Greenland species there are 20 tubercles in a row along the narrowest interambulacral zone, in ours 28. In the broader interambulacral zone there are 15 papillæ in the Greenland species; in ours, 18. Moreover there are fewer flutings in the spines taken from either end of the shell than in our species.

Echinarachnius parma Gray. (E. atlanticus Gray). Abundant and large on sandy bottoms in 2–15 feet.

Psolus Fabricii Lütken. Two were taken in 15 feet on pebbles in Esquimaux Bay.

Pentacta calcigera Stm. (Cucumaria Koreni Lütken). One was taken in 15 feet sand, in Salmon Bay.

Pentacta frondosa Jaeger. One specimen was thrown upon the beach.

Chirodota laeve Grube. Very fine specimens, eight inches long, were abundant in 10 feet sand in Salmon Bay.

Eupyrgus scaber Lütken. Several were taken in 10 feet sand in Salmon Bay. It has not occurred so low down the coast before.

Polyzoa.

Tubulipora patina Johnst. Common.

T. hispida Johnst. Frequent on sertularians in 50 feet.

T. flabellaris Johnst?

Diastopora verrucaria M. Edw. (Millepora verrucaria O. Fabr.) Frequent in 50 feet. I have species from Greenland from which it does not differ, also from the Bay of Fundy.

Stonapora expansa n. sp. Creeping, flat, expanding; the branches widening at the origin of new ones, rugose. Cells in the young long, slender, erect, slightly recurved; arising singly, or in groups of two or three at irregular intervals along the branch. Old specimens broader, cells horizontal, apertures hardly raised above the surface, emarginated.

A small slender white species, the erect tubes in the young longer than the width of the branch. It differs from the European *A. major* in being broader and more expanded.*

Idmonea pruinosa Stm. Frequent from the Bank.

Hippothoa rugosa Stm. Abundant. All the polyzoa here enumerated are, unless otherwise stated, from the Bank, in 50 feet hard stony bottom, occurring on stones, shells, &c.

H. borealis D'Orb. (*H. divaricata* Lamx.?) Abundant.

H. expansa Dawson. Frequent. I have also dredged it at Mt. Desert, Me., in 15 feet.

Lepralia annulata O. Fabr. A group of three cells, with two spines on each side of the distal margin, occurred.

L. crassispina Stm. which I take to be the representative of the European *L. Peachii*, and which assumes its forms, was one of the most abundant species.

L. trispinosa Johnst., or an allied species was very abundant. It is also abundant in Maine, as far south as Portland.

L. pertusa Thomps. I cannot distinguish my specimens by any permanent characters from the British species occurring on a stone with *Crania anomala*. It is oval or broad oval, somewhat flattened or convex, punctured somewhat coarsely, with ridges separating the cells, which are arranged in no special order. Aperture round, truncate behind, or with a broad shallow sinus. The ovi-capsules globose, subrugose, sub-punctate, much as in the British specimens. Found growing in purple patches. Length $\frac{1}{30}$ of an inch, half as broad as long.

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* *S. compressa* n. sp. I have another narrow compressed, very convex species from Greenland. It is adherent, creeping, much rounded above. Cells in a single alternating row, being short and thick, and opening a little outwards; at the end of the branch much thickened and enlarged, giving rise to three or four cells. It varies in the size and relative distances of the cells. William Coll. Exp.

What I take to be a second and larger form of this species has the cells large, oblong, oval, convex, being closely connected with the ones before and behind in radiating lines. The surface has coarse emarginatad punctures. In old specimens the punctures are so large that the surface is often but a network enclosing them Apertures round, slightly raised, with a deep narrow sinus, at the entrance of which are two denticles, one on each side, which often become obsolete. In some cells the surface is perfectly smooth, and only the marginal punctures present.

Specimens from Greenland do not differ. It is much larger than the preceding form, which is $\frac{1}{40}$ of an inch long, and arranged in more regular rows, and preserves better its oblong, oval, convex form. The ovi-capsules are emarginato-punctate, and proportionally smaller and smoother than in the preceding form.

I have also specimens on *Pecten islandicus* from the Newfoundland bank.

L. producta n. sp. (Fig. 1.) Cells oval, convex, coarsely punctate; in the young the punctures are emarginate, the base of the cell is produced and wedged in between adjacent ones. Aperture broad, round, with a moderately large and deep sinus in the young; in older cells, small, round, truncate behind, horse-shoe shaped; margin full, broad, unarmed, and when the cells are crowded, the margin in front expands upon the base of the cell in front. Cells arranged in lines, soon becoming very irregular, and partially radiating; forming white, but more generally purple patches. Length $\frac{1}{30}$ of an inch. Old specimens are flattened, granulated with marginal punctures; very rarely the aperture has a small sinus. It is the largest species observed. Frequent.

As in the preceding species, there are two forms which might easily be mistaken for as many species. The young cells are rounded, ovate, depressed and with emarginate punctures, while the apertures are sinuate. With the other form the species becomes the largest of the genus yet observed on this coast, being one thirtieth of an inch long. The cells are much thickened, convex, in outline often pyriform, owing to the elongation of the base of the cell; and the aperture is small and truncate behind.

In both forms the surface is more than usually rugose.

L. Belli Dawson. Frequent.

L. labiata Stm. One group of this singular species occurred.

L. lineata Hassell. Rare.

L. globifera n. sp. Cells large, flat, white, the surface somewhat raised around the small round aperture, which has a slight sinus. Behind the sinus is a minute perforated conical avicularium. Ovi-cell large, globose, with a few emarginated coarse punctures. Cells in radiating lines, with ridges running between them. The ovi-capsules are more crowded in the centre of the patch, not being present in the inner cells. Frequent, forming frosty white patches. It often encrusts Celleporæ, where the ovi-cells are much crowded, and the ridges between the radiating rows of cells obsolete. I have dredged it in the Bay of Fundy.

Stimpson's *L. candida*, very common in the Bay of Fundy, did not occur in my collection.

Membranipora pilosa Johnst. Especially abundant encircling fronds of Desmarestia just below low-water mark.

M. lineata Busk.

M. Lacroixii Busk? I cannot distinguish these two species from Greenland specimens.

M. solida n. sp. (Fig. 2.) Cells large, flat, solid, oval angulated, often presenting a six sided figure as is common in the genus. Margin raised, simple, very broad and without spines. Aperture occupying one half of the upper surface, transversely broad, oval, with a broad deep sinus; the posterior half of the upper valve is thin, convex subrugose, with a small, triangularly perforate, conical avicularium, situated at the posterior end of the upper surface. Cells arranged in lines, or in quincunces, or more often irregularly. The cells are not so crowded as in the other species. To the naked eye it looks like bleached patches of old worn Lepraliæ.

Beania admiranda n. sp. Cells very large, erect, oval smooth, base produced, sessile. Growing in tufts, the cells arranged in contiguous series, the new cells arising on each side of the aperture of the parent cell. Aperture raised, circular, surmounted by two long stout truncate spines, which are succeeded on the opposite side by two rows of long obtuse spines nearly meeting across the hollow formed by the two ridges on the back of the cell. Compared with *B. mirabilis* of the British coast, this is a much stouter species, growing in low spreading, but not creeping tufts. There are from 6 to 8 pairs of large obtuse spines which meet across the cell; being fewer in number, and longer and stouter than in *B. mirabilis.* More important differences exist in the diameter of the cell being greatest at the distal or anterior third of the cell, where in the British species it is thickest posteriorly; and in our species the aperture opens near the end of the cell. It occurred rarely on Pecten in 50 feet.

Cellularia Peachii Johnst.? With the preceding. Rare.

Menipea ternata Busk? Rare.

M. fruticosa n. sp. (Fig. 3.) This fine species grows an inch in height, with large wide branches, dividing dichotomously. The cells are large and long, being attenuated downwards. Above they are truncated, with four spines, two upon each side, and invariably with an outer projecting spine, when the others are absent. The upper valve is long, oval and sunken; aperture transversely linear, closed by a square incomplete lid. Cells contiguous, arranged in two alternating rows, with two or three median ones before the origin of the branches. The avicularia have long beaks, and are arranged sparsely at the base of the median cells. Long vibracula arise near the front of a few lower valves. The ovi-capsules are globose and smooth. It is more nearly allied to *M. cirrata* of Europe than any other species, though very distinct. It is a common species, and occurs in Greenland, from whence I have a specimen.

Scrupocellaria Americana, n. sp. This species is closely allied to *S. scruposa,* with specimens of which, collected by Dr. Stimpson on the English coast, I have compared it. With much the same habit, our species is twice as large and much more solid. There are the same relative proportions in the form and size of the cells, but in our species the avicularia are smaller in proportion to the cell, and there is but a single spine surmounting this appendage, the lip of the orifice being unarmed, while in *S. scruposa* two spines are very constantly present on the inner side of the cell. The lids or upper valves, which in my specimens are raised from the coenoecium by the relaxation of the muscles, are convex, and somewhat rugose, owing to several slight transverse lines. The ovi-cells are smooth and globose. It is not unfrequent on the Bank.

Caberea Hookeri Busk? One species presents some differences from the British specimens in my possession collected by Dr. Stimpson; and also from Mr. Busk's figures. It is abundant in Labrador, and on the coast of Maine as far as Casco Bay.

Halophila borealis n. sp. (Fig. 4.) This species agrees well in its generic character with *H. Johnstoniæ* Gray from New Zealand, though differing specifically among other respects in being multiserial. The coenoecium forms soft and flexible horn colored tufts an inch in height. The cells in mature specimens are arranged in several contiguous series and are very long, subclavate, truncate, widening a little above, with sometimes a slight spine on the outer angle. The aperture is transversely linear and closed by a slightly sinuate lid. The ovi-capsules are globular and nearly smooth. The upper valves are so thin that in dried specimens it readily contracts and the lid and linear aperture are effaced, and the cell then appears as if it possessed a large, broad, oval aperture, covered by a thin lid.

A single branch consisted in one example of eight rows of cells. A single isolated cell closely resembles a cell of *Flustra truncata*, showing the near relationship of this genus to the Flustradæ. But one tuft of this interesting species occurred in 50 feet associated with *Beania admiranda*, on a fragment of Pecten.

Flustra truncata Linn. Frequent.

F. membranacea Linn. Abundant.

F. Murrayana Busk., 10–50 feet. Abundant. A common species in Maine.

Cellepora pumicosa Ellis. Frequent on sertularians.

Celleporaria surcularis n. sp. Grows two or three inches high, branching dichotomously, the ends of the branches somewhat truncated. Cylindrical, base two or three lines in thickness, surface rough. Cells crowded, of unequal size, erect, conical. Aperture small, with a slight sinus. In the young conical communities, the cells stand out more from the axis; apertures large, round, with a slight, often obsolete, sinus. Surface of the cells coarse, irregular and deeply punctured, often arranged in irregular series running down the sides from the aperture. The terminal cell large and conical. In old species the sinus is sometimes enlarged with two denticles at its entrance. In section the cells are irregularly oval, scattered thickly over the axis and periphery.

Abundant on stems and cells in company with Escharæ.

Dr. Stimpson has placed in my hand specimens belonging to this species, collected by Dr. Hayes in Northern Greenland, and by McAndrew in Manseroe Sound, Finmark. European authors have confounded this arctic species with C. *cervicornis* of the Mediterranean sea, from whence it was originally described by Pallas.

Eschara lobata Lamx. This species Lamoureux describes as growing in radiating patches, always adhering to the surface of objects, and collected near the Bank of Newfoundland. Cells oblong, oval, convex; each end is connected with the cell in front and behind, with a few larger emaginate punctures. Aperture round with a shallow broad sinus. Just behind the aperture a small perforated conical eminence, which in old specimens bears a large avicularium, with long sharp pointed beaks gaping widely; or when absent the cone is large, covering the upper surface of the cell, and furrowed with descending ridges. In communities with ovicapsules, the surface of the cell itself cannot be seen; the capsules are globular, sublunate in form, with emarginated-punctures; the aperture large, often truncate behind. Cells arranged in linear series with intervening ridges.

Occurs spreading over dead Cardium and Serripes in 10-20 feet Salmon Bay, or in 50 feet on the Banks. I have taken it in the Bay of Fundy from low water mark at Eastport to 20 feet.

It is very different from a thin, flat, membranaceous, inverted cup-shaped species that inhabits Massachusetts Bay.

E. elegantula D'Orby. The coenoecium of this fine species grows several inches high in erect branching masses, the branches expanding flat and spreading at the ends. Cells broad, oval flattened, somewhat produced at the base; surface smooth, sub granulated. Aperture round, with a broad shallow sinus. Young cells often margined with a row of large punctures. In old communities the ovi-cells are narrow-oblong, very convex, semi-cylindrical, the cylinder-like avicularia projecting over the aperture, and perforated with a large operculated aperture. Towards the end of the branches, the cells are somewhat cylindrical bearing narrow globular ovi-capsules, which are emarginate-punctured. This is near Busk's *E. saccata* which came either fromNorway or Finmark. It differs however from his figure; and his rather unsatisfactory description does not aid me in determining the species.

Common on the Bank in company with Cellepora. I have specimens also from the Newfoundland Banks. Dr. Stimpson has also specimens collected in Northern Greenland by Dr. Hayes in his last expedition.

Myriozoum subgracile D'Orby. (Fig. 5.) (Millepora truncata Linn. Fabr. F. G.) Frequent with the other species.

Fabricius' description applies well to this species. It grows two or three inches high, branching dichotomously; branches cylindrical, smooth, while at irregular distances slightly contracting,—

passim annulis angustioribus—Cells immersed; apertures round with a very narrow deep sidnus, those at the end of the truncate branches have the *figuram calcei equini* of Fabricius' description. The surface between the cells is deeply and irregularly punctured. A transverse section of a branch shows about twelve oval cells separated by thin walls, arranged around the solid axis of the stem.

This species approaches somewhat Busk's *Eschara teres*, Ann. Nat. Hist., 1856, but it seems to have a more regular form; the oval cells shown in a transverse section are not so much produced towards the central axis of the stem; while it differs wholly from the *teres* in the punctures dotting thickly the whole surface between the cells, instead of there being a single row surrounding the aperture as usual in the genus. *Millepora truncata* is a Mediterranean species, and as represented by Lamoureux, is a much larger and very different form from the two species above mentioned. On the Bank in 50 feet; with the preceding species.

TUNICATA.

Leptoclinum. A species of compound ascidian was abundant in somewhat pellucid masses surrounding branches of nullipores in 15 feet.

Ascidia callosa Stm. Dr. Stimpson has identified this and the species of *Pelonaia.* It is profusely abundant in the Bank in 50 feet growing to a very large size, and affords shelter to various worms, Sipunculi and Modiolariæ, besides serving as a base of attachment to Sertularia, &c.

Cynthia pyriformis Ratke. Several were taken up alive on beaches after storms. Fishermen haul them ashore in their nets.

C. sp. A specimen occurred on *Ascidiacallosa.* It is whitish, smooth, low conical, base expanding.

Pelonaia arenifera Stm. Several occurred in 15 feet sand.

Boltenia oviformis Sav. A young specimen, that I refer to this species was taken on the Bank. It is much more hirsute than the two Maine species.

BRACHIOPODA.

Hypothyris psittacea King. Frequent on hard and sandy bottoms in from 10–50 feet.

LAMELLIBRANCHIATA.

Anomia ephippum Linn. Abundant, though small. On nullipores.

A. aculeata Gm. In from 10–50 feet.

Pecten tenuicostatus Migh. (P. magellanicus Lam.) Is most abundant on a sandy bottom at a fathom's depth. The young were only dredged in 15 feet. The inhabitants call them "pussels" and often eat them. We can bear testimony to the delicacy and rich flavor of this shell fish.

A species of boring sponge, which grows two inches or more in height, its roots boring worm-like galleries in the shell, hastens the decomposition of dead shells very greatly.

P. islandicus Müll. Common in 10–50 feet on a sandy or rocky hard bottom. Valves are occasionally thrown up on beaches.

Limatula sulculus Leach. Several dredged in 15–50 feet sand and gravel.

Nucula tenuis Turton.

N. expansa Reeve. Occurred abundantly with the preceding. Dr. Stimpson has identified our specimens as being this before doubtful species.

Yoldia sapotilla Stm. A few occurred in 10–15 feet.

Leda buccata Stp. Abundant. Does not differ from Greenland specimens.

Crenella glandula Turton. Abundant.

Modiolaria corrugata Stm. In 50 feet.

M. laevigata Gray. With the preceding.

M. discrepans Müll. A valve two inches long was taken from the stomach of cod caught on the Bank.

Mytilus modiolus Linn. Not common.

M. edulis Linn. Abundant.

Alasmodonta arcuata Baines? I was told that a fresh water mussel was common in Salmon River. This must be the same shell that Professor Chadbourne informs me is very abundant in the streams of Newfoundland.

No Cyclades or any other fresh water mollusca were found in the countless pools of the mainland; though a more thorough search than I could make must reveal some forms.

Cryptodon Gouldii Phil. Very large and abundant; a few in 50 feet.

Cardita borealis Conr. Bank 50 feet.

Astarte semisulcata Leach. *A. elliptica* Brown. Bank 50 feet Abundant.

A. Banksii Leach. Frequent with the two preceding shells

Cardium islandicum Chemn. Very abundant and large in Salmon Bay.

C. pinnulatum Conr. Very common, and as large as usual; with the preceding species.

Serripes grœnlandicus Beck. This is a very abundant species, and is a very constant companion of Cardium islandicum, occurring in a mixed sand and mud bottom in 10--20 feet, where it grows to an enormous size.

It varies considerably when old, some specimens being triangular and flattened, with the beaks placed far anteriorly, while other shells are ventricose, oval, with the beaks very central. The young all agree in being short and high, very thick and in having the large swollen beaks placed nearly in the middle of the shells. Some specimens from Greenland differ very much from the Labrador shells in being very triangular, not much longer than high, and having the beaks small and flattened, and placed far anteriorly. Were there not others approaching very closely to some Labrador forms, these characters would easily separate the *grœnlandicus* into two representative species.

Tapes fluctuosa Sby. One valve from the Bank.

Mactra solidissima Chemn. One valve was given me, which was taken three miles inland from the mouth of Esquimaux River on a sand beach.

M. polynema Stm. (M. ovalis Gould.) Rarely thrown up on beaches.

Mesodesma Jauresii Joannis. It is thrown up very abundantly on beaches, of a very large size.

Macoma fusca Stm. Common between tide marks.

M. sabulosa Stm. (T. proxima.) Very large and abundant in 15 feet Salmon Bay.

Solenensis Linn. Rarely taken. Young dredged in 15 feet.

Thracia Conradi Couth. One small specimen was dredged.

T. myopsis Beck. A fine large specimen was dredged in 10 feet mud.

Pandora trilineata Say. A few specimens occurred in 15feet sand.

Pandorina arenosa Möll. One valve was taken with the preceding among nullipores in strong sand, 15 feet.

Cyrtodaria siliqua Daudin. In from 15–50 feet Mostly on hard stony bottoms.

Mya truncata Linn. The short obliquely truncated variety-*uddevallensis* if it should not be considered a distinct species, occurred on the Bank.

M. arenaria Linn. Abundant.

Saxicava rugosa Linn. Common in 10--50 feet Limestone pebbles are often fished up from the Gulf, which are bored into in every direction by these shells, which are then become short and much thickened.

GASTEROPODA.

Clione limacina Phipps. (Clio borealis Brug.) Seen frequently floating near the surface in calm weather.

Proctoporia ? sp. A species with an expanded foot was taken in 50 feet on the Bank. It was not discovered until immersed in alcohol, and is undistinguishable, though it differs from anything in New England, approaching rather Fabricius' figure of *P. fusca.* No other species of Nudibranchs, were found, though the ova frequently occurred in round masses on sea weeds in the *Laminarian* zone.

Cylichna alba Lovèn. Several large specimens with a thin brown epidermis, and differing in no respect from one from Greenland, occurred in 10–15 feet mud and sand.

Philine lineolata Stm. Frequent, with the preceding.

Chiton marmoreus Fabr. From low water to 50 feet.

C. albus Linn. Several in 50 feet.

Tectura testudinalis Müll. Largest and most abundant at low-water mark. The young were dredged in 15 feet.

Diadora noachina Gray. Several in 10–50 feet.

Scissurella crispata Flem. Dr. Dawson has detected this species in sands examined for Foraminfera, as also the following species.

Adeorbis costulata Stm.

Margarita cinerea Gould. Grows largest on sandy bottom in 50 feet.

M. undulata Sby. and Brod. Common in 15–20 feet sand.

M. helicina Möll. Common, 2–15 feet.

Rissoa minuta Stm. One dead specimen occurred above high water mark.

Rissoa castanea Möll. R. exarata Stm. 15 feet sand.

Lacuna vincta Turt. The plain and banded varieties were common.

Littorina vestita Gould. *T. vestitus* Say L. rudis Gould.

L. palliata, Gould. *L. littoralis*, F. and H. Both these species occurred abundantly and with variations, as in Maine.

Scalaria grœnlandica Perry. A fragment only occurred.

Turritella erosa Couth. Abundant.

T. reticulata Migh. Very abundant, occurring with the preceding in 10–50 feet, but most abundant in 15 feet mud. Salmon Bay.

T. acicula Stm. One individual in 50 feet hard bottom.

Menestho albula Möll. The young were frequent in 2–15 feet sand.

Lamellaria perspicua Lovén. 15 feet sand and mud.

Natica heros Say. Two young dead shells were found at high water mark.

N. clausa Sby. Frequent in 15 feet.

Bela violacea Stm. (Pleurotoma violacea Migh. and Adams.) 18 feet. Both this and the *bicarinata* Couth., which Dr. Stimpson considers but a variation of the *violacea*, were frequent in 20 feet sand.

B. decussata Stm.

B. scalaris, (Defrancia scalaris Möll., Ind. Moll. Grön. Fusus turricula Gould.)

The European *B. turricula*, as observed by Mörch, is very different from the American representative. On a comparison of our shell with several specimens of the *turricula*, we find that the shoulder on each whorl that gives the shell its turreted appearance, is situated more in the middle in *B. scalaris*. The *turricula* has twelve longitudinal ridges on each whorl, being fewer and proportionately larger than in our species which has seventeen. Our species seems also to be a larger shell. It agrees well with Möller's *D. scalaris* to which he refers *turricula* Gould

B. Woodiana Möll. Fusus harpularius Gould.

One specimen was dredged with the preceding [illegible] have also two specimens of it from Greenland. It is a shorter and thicker shell than *B. scalaris*, in which the first whorl is as long as the remaining ones together. In this species the first whorl is longer than the rest. The canal is shorter and the aperture rounder. The longitudinal ridges are the same in number, but are less prominent, while the revolving lines are much coarser, giving the surface a reticulated appearance.

B. pyramidalis Stm.

These species of Bela occurred in sand and mud 15 feet Salmon Bay. B. decussata was the most abundant species.

Buccinum labradorense Reeve. Icon. Conch., pl. 1, fig. 5. Most abundant just below low water mark. Fine specimens 3½ inches long were frequent; their egg capsules in large bunches were often deposited at low water mark. This species represents the European *B. undatum*.

B. scalariforme Müll. One specimen on the bank.

B. cretaceum Reeve, Icon. Conch., Monogr. Bucc., pl. 14, fig. 112. Shell fusiform, slender, nearly three times as long as broad. Aperture oval, ending in a rather long, broad, oblique canal. Inner lip regularly curved; the columella projecting into the aperture at the base of the canal; from this projection a slight ridge runs back to the other end of the aperture, following the curve of the inner lip. Whorls 9, convex, especially on the upper two thirds. Spire much prolonged, acute. 21 longitudinal ridges, smooth and rounded. On the first whorl the ridges disappear on the lower two thirds, where the minute revolving lines are more minute than elsewhere. Aperture within, light chocolate, darker in the young, in which the revolving lines are more distinct. Length $\frac{21}{20}$ in., breadth $\frac{3}{10}$ in.

The slender and fusiform shape, and greater length of the spire than is found in other northern species, will distinguish it. The young and old were dredged alive in 10 feet mud and sand, Salmon Bay. Dr. Stimpson informs me that he has seen specimens from the Newfoundland Banks. It seems to be identical with Reeve's species, of which he gives no locality.

Fusus tornatus Gould. A large specimen, tenanted by a hermit crab, was dredged in 50 feet.

Trichotropis borealis B. and S. Frequent in 10–50 feet.

Admete viridula Stm. Thick heavy specimens, an inch in length, were dredged in 40-50 feet.

Trophon scalariforme Stm. Large specimens from the Bank.

Bulimus harpa Say. One dead shell was found in moss. The only Helicid found.

CEPHALOPODA.

Ommastrephes. A squid, the fishermen informed me, sometimes comes ashore in swarms, or is fished up from deep water.

ANNELIDA.

Sipunculus n. sp. It is very different from *S. Bernhardus*, being larger, proportionately thicker, while the anterior third is suddenly rounded and cylindrical. Found between Ascidiæ on a hard bottom in 50 feet.

Cerebratulus n. sp. Occurred with two other species of nemerteans, in 10 feet mud.

Spirorbis spirillum Lam.

S. nautiloides Lam.

S. vitrea Stm.

S. porrecta Stm.

S. cancellata Fabr.

S. glomerata Müll., Fabr. F. G. Large, round, smooth, aperture round, sinistrose, raised slightly from the whorl beneath. The adult shell is not flattened out beneath upon the surface of objects, but nearly free.

Diameter of the tube $\frac{1}{10}$ in., of the whole shell $2\frac{1}{2}$ tenths. The largest species observed occurring on the edges of Cardum in 10 feet mud, but more abundantly in company with the preceding species in 50 feet hard bottom. Other specimens are a little smaller, but with a slight ridge on the upper surface, occurred with it. I have a specimen of this form also, from Greenland, together with the slightly curved and flattened convex young shells.

S. quadrangularis Stm. With the preceding species.

Vermilia serrula Stm. Abundant with the preceding.

Pectinaria Eschrichtii Rathke. Very abundant and large, especially in 10 feet mud on fish offal thrown overboard from fishing vessels. One was taken at low water mark.

Terebella n. sp. 50 feet Bank.

Siphonostomum plumosum Müll., 10 feet mud.

Cirrhatulus n. sp.

Nephthys coeca Fabr.

Heteroneis arctica Oersted. One specimen was found swimming on the surface.

Eteone sp.

Nereis pelagica Linn.

Nereis n. sp. Allied to *denticulata*, and like that found in mud between tide marks.

Lepidonote cirrata Oersted. 10–50 feet.

L. punctata Oersted.

CRUSTACEA.

Cytherina Mulleriū? In 15 feet gravel.

Cytherina sp.

Daphnia? A very large species, two tenths of an inch in length is abundant in fresh water pools. It is not the *D. retispina* of Greenland.

Phoxichilidium sp. At a little below low water mark.

Nymphon grossipes Kroyer. In 50 feet Bank.

Coronula diadema. On the grampus.

Balanus balanoides Linn.

B. porcatus Da Costa.

Cuma sp. A little below low-water mark.

Jaera copiosa Stm. Common near high-water mark.

Aega sp. On the belly of cod.

Unciola irrorata Say.

Anonyx sp. In 15 feet gravel.

Anonyx sp.

Ampeliscus pelagica Stm.

A. Eschrichtii Kr.

Gammarus purpuratus Stm. In 10 feet mud and sand.

G. mutatus Liljeborge. (G. pulex). Occurs as in Maine.

Mysis spinulosus. In swarms in tidal pools. The sea trout feed on it.

Hippolyte spini. (H. Sowerbyi Leach). Frequent in 10--50 feet

Crangon vulgaris Fabr. Very large and abundant.

Argis lar Owen. This fine species occurs rarely in 10 feet mud.

Homarus Americanus M. Edw. Common.

Eupagurus pubescens Stm.

E. Kroyeri Stm. Both species from below low-water mark to 50 feet.

Hyas coarctata Leach.

Hyas aranea Leach. Both species common.

Chionocetes opilio Fabr. A number were taken from stomachs of cod from the Bank.

Cancer borealis Stm. Common under sea weed.

To make the list of species of this region as complete as possible, I add the following radiata from Newfoundland, on the authority of Lütken.*

Astrophyton eucnemis M. and T.; *Ophiura Stuwitzii* Lütk.; *Ophioglypha nodosa* Lyman—(*Ophiura nodosa* Lütken.); *Solaster papposus*, *S. endeca; Asteracanthion polaris* M. and T., *A. Grœnlandicus* Stp.; *Echinus Dröbachiensis*, small specimens and *Psolus Fabricii.*

Also the following mollusca from the Grand Bank, mentioned by Dr. Gould:

Solecuartus fragilis, *Machaera nitida*, *Panopaea Norvegica*, *Glycimeris siliqua*, *Mya truncata*, *Mactra ponderosa*, *polynema* Stm., *Mesodesma deauratum*, *Astarte lactea*, *Venus* (*Tapes*) *fluctuosa*, *Aphrodite Grœnlandica*, *Mytilus discrepans*, *Pectend islandicus*, *Natica clausa*, *N. flava*, *Scalaria Grönlandica Fusus ventricosus*, *F. tornatus*, *F. scalariformis*, *Aporrhais occidentalis*, *Buccinum Donovani*, *B. ciliatum*. Also a few species from Labrador, mentioned by Dr. Mighels. Bos. Jour. Nat. Hist., Vols.1 and 4 : *Cardium pinnulatum*, *Nucula rostrata*, (*N. buccata?*) *Mytilus pectinula*. *M. Minganensis*, *Margarita acuminata*, Sby., *M. varicosa*, *Fasciolaria ligata*, *Fusus islandicus*.

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* Uebersicht über Grönland's Echinodermata.

Woodward also mentions *Astarte crebricostata*, *Cyprina islandica*, *Machæra costata*, *Buccinum undulatum* Müll., *B. Labradorense* Reeve, *B. cyaneum*, *Lacuna*——, and *Ommastrephes todarus* d'Orb., as coming from Newfoundland. Sowerby, in the "Thesaurus," figures *Terebratella Labradorensis*. Troschel in Wiegmann's Archiv., 1846, describes *Anaperus cigaro*, and *Orcula Barthii* collected at Okkak in northern Labrador.

Professor Chadbourne informes me that *Pecten tenuicostatus* and *Alasmodonta arcuata* are very abundant and characteristic shells in Newfoundland.

Reeve (Icon. Conch. Monog. Fusus, pl. 21, fig. 89) figures and describes *Fusus pullus*, which was collected at Newfoundland by Mr. Jukes.

Lamoureux, in his "Exposition Methodique des Polypiers," has figured and described several species of Polyzoa collected by Captain Laporte upon or near the Bank of Newfoundland: *Loricaria Americana*, of which *Gemellaria dumosa* Stm., seems to be a synonym; *Eucratea appendiculata*, and *Eschara lobata*, besides one Acaleph, *Lafoea ramosa*.

Gemellaria Americana d'Orb., *Eschara retiformis* Ray, (= E. foliacea Lamk), *Eschara lobata* Lamarck, *Eschara elegantula* d'Orb., *Celleporaria incrassata* d'Orb. (Cellepora incrassata Lamarck), *Celleporina ramosissima* d'Orb., *Biflustra aculeata* d'Orb., *Ornithoporina avicularia* d'Orb., Hudson's Bay. *O. dilatata* d'Orb., *Semieschara lamellosa* d'Orb., *Hippothoa borealis* d'Orb., *Hippothoa robertina* d'Orb., *Cellepora* sp. (none described), *Reptocelleporaria tuberosa* d'Orb., *Repteschareliina borealis* d'Orb., *Multescharellina aculeata* d'Orb. var., *Membranipora partita* d'Orb., *Reptoflustrella Americana* d'Orb., *Cridia appendiculata* d'Orb. (= Eucratea appendiculata Lamx.), *Myriozoum subgracile* d'Orb., *Fasciculipora Americana* d'Orb., *Idmonea angustata* d'Orb., *Reptotubigera confluens* d'Orb., *Entalopora Gallica* d'Orb., *Diastopora latomarginata* d'Orb., *Tubulipora verrucaria* Edwards, *Proboscina serpens* d'Orb., *Proboscina latifolia* d'Orb., *Berenicea prominens* Lamx.

Mr. Verrill has identified specimens of a polyp in the collections of the Essex Institute, (Salem, Mass.) brought from the Grand

Bank of Newfoundland, as *Alcyonium rubiformis* Dana, (Ehr. sp.)

I have permission to introduce in this connection :

A LIST OF THE INVERTEBRATA COLLECTED AT ANTICOSTI AND MINGAN ISLANDS, by Messrs. A. E. Verrill, A. Hyatt, and N. S. Shaler, in 1861, who have allowed me to make this use of the names given below. The specimens are deposited in the Museum of Comp. Zoology at Cambridge, Mass. The list of radiates and the accompanying notes were furnished me by Mr. Verrill.

POLYPI.

Metridium marginatum E. and H., (Actinia marginata Les.)? Several young actiniæ were dredged in 8 feet,at Ellis Bay, Anticosti, adhering to rocks, which appeared to belong to this species. No other polyps were obtained at these islands. At Gaspé, C. E., Prof. Dawson obtained this species, and has described and figured it very accurately,* (Actinia dianthus ?). With it he also found *Actinia carneola* Stimp. In Chedabucto Bay on the southern side of Breton Island, N. S., we dredged an abundance of *Alcyonium carneum* Ag., in 10 feet rocky bottom, associated with a variety of hydroids. This is the most northern locality yet known for the species, its range being southward to Cape Cod.

ACALEPHAE.

Pleurobrachia rhododactyla Ag. Very abundant about East Point, Anticosti, in July.

Idyia roseola Ag., East Point, Anticosti. Very abundant the first of July.

Bolina alata Ag. Near Fox Bay, Anticosti. Very abundant June 29.

Cyanea arctica Per. and LeS. Anticosti. Common. Young about 1 inch in diameter were taken at Fox Bay, June 28.

Aurelia flavidula Per. and LeS. Eastern end of Anticosti. Common. Young ones ½ inch in diameter were taken at Salmon River Bay, July 2.

Haliclystus auricula Clark. (Lucernaria auricula Rathke, non Fabricius.) Near S. W. Point, Anticosti. Very abundant on *Chorda filum*, Aug. 14, at low water. Another species of Lucernaria was taken, but the specimen was lost.

Cosmetica sp. A beautiful species of this genus, about 3 inches in diameter,with large tentacles about two inches long and half an inch apart, was found in great abundance, June 25, at Entry Island, in the caverns excavated in the high cliffs of red sandstone by the sea.

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* Canadian Naturalist and Geologist, vol. 3, p. 401.

Hydractinia polyclina Ag. Anticosti and Mingan. Common.

Sertularia polyzonias Johnst. Niapisca Is. Mingan. In 15 feet rocky bottom.

S. argentea Johnst. “ “ “
S. rosacea Johnst. “ “ “
Eudendrium sp. “ “ “
Clytia olivacea Lamx. “ “ “
Thuiaria thuja Johnst. “ “ “
Plumularia falcata Lamx. Anticosti.

ECHINODERMATA.

Pentacta frondosa Jæg. Anticosti, near Ellis Bay. Not common. A fine young specimen was found among rocks at low water.

Chirodota lœvie Grube. Anticosti, near Ellis Bay. Several specimens were found under rocks at low water.

Echinus drobachiensis Müll. Anticosti and Mingan Is. Very common in 20–30 feet, rocky bottom.

Echinarachnius parma Gray. (E. atlanticus Gray). A few small specimens were dredged at Mingan.

Asteracanthion polaris M. and T. S. W. Point and Heath Point, Anticosti. Common among rocks just below low-water mark. Also dredged in 15 feet rocky bottom at Mingan Is.

Asteracanthion sp. A form with longer rays and sharp spines was obtained at Gaspé, C. E.

A. Grœnlandicus Stp. A single specimen was dredged in 15 feet rocky bottom off Ellis Bay, Anticosti.

Cribella oculata Forbes. Heath Point. Common.

Ophiopholis aculeata Lütken. Anticosti and Mingan Is. Very common in 10--15 feet rocky bottom. Cod-fish were often caught having their stomachs filled with this species.

Ophioglypha robusta Lyman. A single specimen dredged in 20 feet, rocky bottom, off Table Head, Anticosti.

Astrophyton Agassizii Stimp. A specimen of this species, obtained near Gaspé, C. E., was presented by Rev. I. A. Tallman.

POLYZOA.

Tubulipora patina Johnst. Anticosti.

Diastopora verrucaria Fabr. sp.

Membranipora Lacroixii ? Sav. All these species occur at Mingan in 15 feet.

Lepralia annulata Fabr.
L. trispinosa Johnst.
L. hyalina Johnst.
L. Belli Dawson.
L. pertusa Johnst.
L. paucispina Stimp.
Eschara lobata Lamk.
Myriozoum subgracile d'Orb.

D'Orbigny in the Paleontologie Française, Terrain cretacés 1850-52, has described a large number of Polyzoa from the Bank of Newfoundland, a list of which is here given :

BRACHIOPODA.

Hypothyris psittacea King. One specimen occurred at Anticosti in 20 feet, rocky bottom.

LAMELLIBRANCHIATA.

Mytilus edulis Linn. Anticosti.
Saxicava arctica Desh. Anticosti.
Mya arenaria Linn. Anticosti.
M. truncata Linn. Anticosti.

These four species, together with *B. Labradorense* and *P. lapillus* and *Cancer irrorata*, were all that occurred during a walk along the shores of the island for 12 miles. Owing to the freshness of the water, there was a remarkable paucity of littoral animals noticed.

Pecten islandicus Müll. Mingan, 20 feet.
Crenella glandula Turton. Anticosti, 20 feet.
Cardita borealis Conr. Mingan, 20 feet rocky.
Cardicum islandicum Chemn. Mingan, 20 feet rocky, abundant.
Serripes Grœnlandicus Beck. With the last; large and abundant.

GASTEROPODA.

Doris sp. Not described.
Chiton marmoreus Fabr. Mingan.
Margarita undulata Sowb. Mingan.
M. cinerea Gould.
M. helicina Müll. Anticosti, abundant.
M. varicosa Mightes. Mingan Is. 20 feet rocks, common.
Turritella erosa Couth.
Aporrhais occidentalis Beck.
Lacuna vincta Turton. Anticosti.
Littorina vestita Gould.
L. palliata Gould.
Purpura lapillus Lam. Anticosti. Not very common.

Buccinum Labradorense Reeve. (B. undatum Gould). Anticosti. Not very common.

Fusus tornatus Gould. Mingan Is. 20 feet rocky. One large dead shell.

Bela Woodiana Möll. Mingan, 20 feet rocky.

Physa heterostropha Say. Occurred on the south side of Anticosti in great abundance.

Limnæa. A species was common in ponds at Anticosti.

Vitrina pellucida Drap.? Common at Anticosti and Mingan.

Succinea obliqua Say. Common at Anticosti and Mingan. Fright Island, and Niapisca Island.

S. avara Say. Frequent at Mingan under drift stuff, boards, and rocks near the shore, where all the terrestrial species mentioned from Labrador occur. But those mentioned from Anticosti were found all over the island, in the interior as well as on the shore.

Pupa badia Adams. Abundant at Fright Is., Mingan.

Bulimus lubricoides Stm. Common at Niapisca Is., Mingan.

Helix chersina Say. Frequent at Fright Is.

H. nemoralis Linn. Both the plain and striped varieties were found on plants at Anticosti.

H. arborea Say. Common at Niapisca Is.

H. minuta Say. Common at Anticosti.

H. striatella Anthony. Abundant at Fright Island and Niapisca Island.

Limax campestris Binney. Frequent at Anticosti.

At Entry Island, one of the Magdalen group, in the centre of the island under boulders, occurred and in the usual abundance, *Helix nemoralis, arborea, lineata, striatella, electrina*, and *Bulimus lubricoides.*

At Chedabucto Bay *Pandorina arenosa*, young shells, alive, *Margarita acuminata* and *Nassa trivittata* were dredged by the same party.

ANNELIDA.

Omatoplea Stimpsoni Girard. Anticosti, 15 feet rocky bottom.

Nereis sp., allied to *denticulata.* Anticosti.

Lepidonote cirrata Oersted. Anticosti.

L. punctata Oersted. Anticosti and Mingan.

CRUSTACEA.

Hippolyte aculeata Fabr.

H. polaris Sabine.

H. Fabricii Kroyer.

H. Gaimardii M. Edw.

Argislar Owen. This and the four preceding occurred at the eastern end of Anticosti in 20 feet rocky bottom.

Homarus Americanus M. Edw. Common.

Eupagurus pubescens Stimp. Anticosti, 20 feet common.

Cancer borealis Stimp. Common.

Hyas aranea Leach. Common.

Gammarus mutatus Leily. Low water, abundant.

Idotea new sp. Low water and 10 feet, common.

Caprella. Two species, 20 feet, common.

Calliope lævinscula. Magdalen Isles. Abundant at the surface of the water in the caverns under eroded cliffs.

Themisto sp. Anticosti, common.

Pandalus annulicornis Leach. Anticosti, 15 feet.

Argis lar Owen. Mingan, 15 feet Niapisca I.

Homarus Americanus M. Edw. (Lobster.)

Hyas aranea Linn. At Ellis Bay, Anticosti, in 8 feet rocks.

Cancer irrorata Say. Anticosti.

These articulata were identified by Dr. Stimpson.

Crangon boreas has been brought from Labrador by H. R. Storer, M.D.

Though the above lists of species are imperfect, yet they seem to afford very satisfactory evidences that there are three distinct assemblages of marine invertebrates intermingled on the coast of southern Labrador. We can easily separate from the list, as foreign to this coast, three species of moluscs; viz. *Pandora trilineata*, *Natica heros*, and *Rissoa minuta*. These shells were rare, and of small size, though on the coast of New England they are large and abundant.

By the aid of "The Invertebrata of Massachusetts," by Dr. Gould, and a list of invertebrates found by Mr. Robert Bell, Professor of Natural Sciences, in Queen's College, Kingston, about the mouth of the St. Lawrence and the coast of New Brunswick, published in the Canadian Naturalist and Geologist; together with a list of the shells of Halifax by Mr. Willis, and Stimpson's Invertebrates of Grand Manan, we are enabled to trace the fauna peculiar to the coast from Cape Cod to Nova Scotia, as it reappears again in the Eastern shores of the Gulf of St. Lawrence, about Prince Edward's Island, at Gaspé, and extends up the river St. Lawrence towards Quebec.

Some of the following shells do not occur at Grand Manan, but seem to be as abundant on the shores of Canada as in Maine:

Leda limatula.
Mytilus plicatulus,
Venus mercenaria.
Lyonsia hyalina.
Ostrœa virginiana.
Crepidula plana.
" *fornicata.*
Rissoa minuta.
Natica heros.
" *triseriata.*
Nassa trivittata.

Mr. Bell observes that *Natica heros* is "large and abundant." *Mytilus plicatulus* and *Venus mercenaria* were "from the Gulf.". The last mentioned species occurs abundantly in Casco Bay- *Eupagurus Bernhardus*, which does not occur in Labrador, was frequent. *Aporrhais occidentalis* occurred very rarely at Gaspé, as it does on the coast of Maine.

The occurrence of the large long oyster so common at Prince Edward's Island, and which is found in such immense heaps at Newcastle, Me., upon the banks of the Sheepscot River, in whose waters it still lives, though in diminshed numbers, indicates similar oceanic conditions existing on those two shores, which are separated by the colder waters of the Bay of Fundy.

The occurrence of *Astrophyton Agassizii* at Gaspé, which is replaced in Labrador by *A. eucnemis*, is interesting as showing that the echinoderm faunæ of those localities are also distinct. The island of Anticosti, judging by its land shells and vegetation and the presence of *Idyia roseola*, *Bolina alata*, and *Pleurobrachia rhododactyla*, belongs to New Brunswick.

This fauna was stated by Dr. Gould to extend from Cape Cod to the Newfoundland Banks from the study of the mollusca alone. It was afterwards, by Forbes, termed the "*Boreal*" province, and he considered Cape Breton its most northern limit.

In 1852, Dana[*] established under the name of the "Nova Scotian Province," a crustacean fauna, embracing an extent of nine hundred miles, reaching from "Cape Cod to the Eastern Cape of Newfoundland;" and in 1857, Lütken[†] likewise proposed for the same region an echinoderm fauna, which he calls the "Acadiske Provinds," merely changing Dana's name for the more ancient title of that Province.

They all agree in bringing down the Arctic or polar fauna to intermingle with the Acadian fauna at the northern limits of the latter. But with a better knowledge of the polar fauna, which is presented in the lists of Greenland invertebrates by Reinhart, Mörch, Lütken, and others,[‡] we are led to the conclusion that there is an intermediate fauna inhabiting the seas of Labrador and Newfoundland.

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[*] Crustacea of the U. S. Exploring Expedition.

[†] Uebersicht über Grönland's Echinodermata.

[‡] Naturhistoriske Bidrag til en Beskrivelse af Grönland. Kiobenhavn, 1857.

A large portion of the polar species have not yet been discovered south of Greenland; and the following species are characteristic of Labrador and the Banks of Newfoundland:

Cyrtodaria siliqua.
Asterias n. sp?
Anaperus cigaro.
Orcula Barthii.
Terebratella Labradorensis.
Pecten tenuicostatus.
Alasmodonta arcuata.
Mesodesma Jauresii.
Machæra nitida.
Margarita acuminata.
" *varicosa.*
Natica flava.
Aporrhais occidentalis.
Fasciolaria ligata.
Buccinum cretaceum.
Fusus ventricosus.
Ommastrephes todarus.

The littoral species of south-eastern Labrador agree well with those of Maine. The two species of *Littorina* present the same variations, and the *Macoma fusca* occurs in the same abundance. These three mollusks are replaced in Greenland by representative species; as regards the latter, Dr. Stimpson has separated this species from *Tellina Grœnlandica* Beck; and my own specimens from Greenland are plainly distinct. The genus Mesodesma, which does not occur in Greenland, is represented by two species in Labrador and the Grand Banks. The fresh water *Alasmodonta arcuata*, which is so abundant throughout Newfoundland, and in Nova Scotia, New Brunswick, and the eastern half of Maine, which is included in what was formerly called "Acadia," also characterizes this fauna. In the deep water species there is a greater similarity to the polar fauna, but many species of Buccinum and Fusus described from the frozen seas, which have not been found to the southward, show plainly a different fauna adapted to those climatic conditions. Most of the species enumerated in the preceding list extend around Cape Breton to Halifax and the Banks lying off Nova Scotia, and predominate at the mouth of the Bay of Fundy; but along the coast of Maine they become reduced in size and numbers before reaching the mouth of the Penobscot. The fauna also reappears on St. George's Banks, and very probably on Jeffries Bank, and the occurrence of *Eupagurus pubescens** and *Cardita borealis*, a very abundant Labrador and Greenland shell, off the coast of New Jersey, indicates that the cold arctic current impinges upon that coast. How far northward of Newfoundland this fauna extends is not now known. The charts show the existence of an immense shoal to the northward of that island, which with the opposite coast of Labrador is no doubt occupied by this fauna. Returning down the coast we find it following very closely the line of floating ice as laid down in the charts. It includes the Mingan Islands, partially embracing Anticosti, and then sweeps around towards Cape Breton, there meeting the warmer waters of the Gulf Stream.

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* Forbes' Natural History of the European seas, p. 53.

Thus, south of Labrador, it is apparently a *shoal* fauna, and we would propose for it the name of the *Syrtensian Fauna*, indicative of the physical features that limit its bounds.

This fauna seems to have its equivalent upon the European side of the Atlantic in Finmark, where Lövén* records the discovery of several new species of Mollusks and other invertebrates. The climatic conditions are very similar, and the insect fauna and the flora correspond very exactly with the insects and plants of Labrador.† Indeed, there is apparently a belt of faunæ intermediate between the boreal province on both sides of the Atlantic on the one hand, and the circumpolar province, which touches upon the southern point of Greenland, includes Iceland, and spreads out so as to include Finmark and the neighboring islands. Dr. Gould, in noticing the distribution of our mollusks, mentions the fact that "about 20 species may be regarded as intermediate, being found most frequently by fishermen about the Banks, Newfoundland, and the islands intervening between Greenland and England. (Invertebrates of Massachusetts, p. 316).

Thus with our present knowledge we can approximate very nearly to the southern limits of this *shoal* fauna, and trace the isolated patches situated upon the cold and unprotected elevations, which rise in the warmer seas of New England; but our imperfect information respecting the range northward of its most characteristic species, does not allow us to speak with much certainty how far up the eastern coast of Labrador these species extend, or whether those few species, which reach Greenland and occur there rarely, may not be considered as foreigners to the soil. For example: of *Apporhais occidentalis*, which is so profusely abundant in the Straits of Belle Isle, Mörch reports but a fragment from Greenland. This is analogous to the occurrence of

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* Identified by Dr. William Stimpson..

† In a communication to the Boston Society of Natural History, "Proceedings," 1863, Mr. S. H. Scudder has intimated that there is an insect fauna peculiar to Eastern Labrador, and in conversation with the writer, has also spoken of the close analogy, which the insects of Labrador bear to those of Lapland.

Cardita borealis on the New Jersey coast, where it is certainly an alien.

In the absence of requisite data concerning the distribution of marine life in the arctic and subarctic seas, we shall be very materially aided by tracing the course of the yearly isothermal lines; and more especially for our purpose that area of the Atlantic ocean comprised between the line of 40° and 32°. The line of 40°, according to Professor Henry*, begins in America at the Northern portion of Nova Scotia. This agrees well with Gould's and Forbes' designation of Cape Breton, as being the dividing point between the Acadian and Arctic provinces. The line of "32° indicates the boundary of the region within which the average temperature is below the freezing point. It will be seen at a glance, that, instead of being circular in its outlines, it has the form of an irregular elongated ellipse, the greater diameter of which is across the pole, from the southern extremity of Hudson's Bay, to the south of Lake Baikal, in Siberia." Upon the map accompanying the report, the line is made to pass through the lower third of the eastern coast of Labrador, dividing Cape Farewell from the remaining portion of Greenland, and touching Europe at Finmark in the vicinity of Nordland, one of the most southern of the Lofoden Islands. Thus to the north it shuts out a vast circumpolar region, including the northern portion of Hudson's Bay, with all of Baffin's Bay; and upon the European side it includes Spitzbergen and Nova Zembla. We are therefore confirmed in our opinion formed before meeting with these meteorological facts, that this elliptical area embraces a belt of faunæ of a subarctic character; and in the supposition that the fauna of Labrador and the Newfoundland banks has an European equivalent fauna in Finmark, occupying an extent of perhaps some 400 miles along the coast from Nordland to a point somewhere beyond Cape North.

Brunswick, Maine, Aug. 1863.

EXPLANATION OF THE FIGURES.

Pl. s. I. II. Fig. 1. Lepralia producta Pack.
" 2. Membranipora solida Pack.
" 3. Menipea fruticosa Pack.
" 4. Halophila borealis Pack.
" 5. Myriozoum subgracile D'Orby.
" 6. Buccinum cretaceum Reeve.

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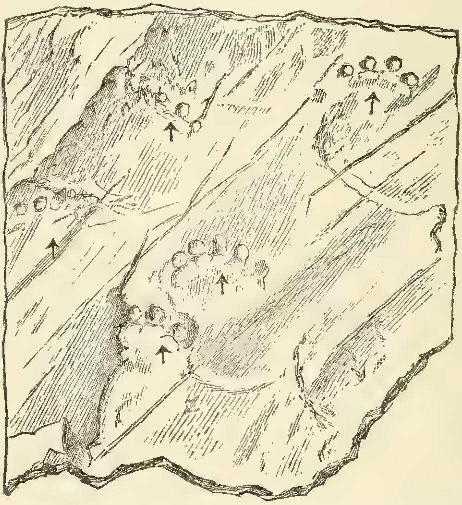
* Meteorology in its connection with Agriculture. Patent Office Report on Agriculture, 1856.

Art. XXIX.—*Note on the Foot-prints of a Reptile from the Coal Formation of Cape Breton.*

Since the publication of my memoir on the "Air-Breathers of the Coal Period," my friend Richard Brown, Esq., of Sydney, Cape Breton, has favoured me with a photograph of a series of footprints from the Sydney Coal-field. They occur in a bed of rippled sandstone, and are sufficiently distinct to render it certain that they indicate the existence of a reptile as yet unknown to us by other remains.



The slab exhibits with some distinctness three foot-prints of the right side, and less distinct traces of the left feet. The feet are short and broad, the fore foot as large as the hind foot, the toes short, broad and deeply impressed in the sand. Four toes are distinctly marked in both fore and hind feet, and there are uncertain traces of a fifth. The stride is considerably greater than the breadth of the body. The toes are somewhat turned inward. The figure is reduced one fourth, so that the animal must have been rather larger than *Dendrerpeton Acadianum*, with shorter toes and broader body.

These foot-prints are quite different in form from those previously found by Sir W. E. Logan, Dr. Harding, and the writer. They more nearly resemble those figured by Dr. King and Mr. Lea from the carboniferous of Pennsylvania; and may have been produced by an animal generically related to that which has left the traces named *Sauropus primævus* by the latter author. For this reason, until we shall obtain some knowledge of the animal from more definite remains, I propose for it the name of *Sauropus Sydnensis.* The specimen was discovered by Mr. Brown, and is now in his collection.

These footprints add a ninth species to the reptilian fauna of the Coal Formation of Nova Scotia, and are the first traces of this kind discovered in the Cape Breton Coal-field.

J. W. Dawson.

Art. XXX.—*Synopsis of the Flora of the Carboniferous Period in Nova Scotia;* by J. W. Dawson, LL.D., F.R.S., F.G.S., &c., Principal of McGill College.

The following list includes the plants in the collection of the writer, and in collections submitted to him by several geological friends; as well as those previously catalogued by Mr. Bunbury, in Sir Charles Lyell's Travels, and in the Journal of the Geological Society, and by Mr. R. Brown and the author, in the list appended to "Acadian Geology."

The present synopsis was not prepared so much for immediate publication, as in aid of the writer's investigations of the characteristic plants in the numerous coal beds at the South Joggins, and of the conditions of formation of those beds; but as some time may elapse before the publication of these researches, and the want of a list of the known species is much felt by those engaged in the study of the carboniferous rocks, it has been thought advisable to print it in the present form.

The new species are accompanied by short characters; but many of the details which might have been given are omitted for the sake of brevity. The collectors of the specimens examined are mentioned in every case, when known to the author. The part of the carboniferous system in which the species occur has also been stated; and as some confusion has lately arisen from the use of the term "sub-carboniferous," by authors, it is proper to state that the name "*Lower coal formation*" in this paper is equivalent to "sub-carboniferous" of Dana; that "*Middle coal formation*" denotes that part of the system over the Marine Limestones and holding the principal coal beds; and that "*Upper coal formation*" is applied to the newer part of the system over the productive coal measures.* These three members are, to a certain extent, distinct in their flora. Any minor differences which exist in subordination to these main divisions, will be fully detailed in the memoir on the coal beds of the Joggins already referred to.

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* These groups are indicated in the following pages by the initials L. C., M. C., U. C.

I have included in the list such plants from New Brunswick as are known to me. Those from Grand Lake in that Province are I believe on the horizon of the middle coal formation, though tending to the upper. A collection formed by Sir W. E. Logan at Baie de Chaleur, in beds of the lower and probably middle coal formation, includes also some species which in Nova Scotia are more characteristic of the upper coal formation. This apparent mixture of plants of different horizons, may be a consequence of the comparatively small thickness of the New Brunswick coal formation.

In the present unsettled state of the species of coal plants, it is with much diffidence that I venture to publish this list, which will without doubt admit of many corrections and improvements, even in the memoir on the formation of the Nova Scotia coals, with which I propose to follow it. I have, however, endeavoured to avoid adding to the load of synonyms, and have in all doubtful cases leaned to the side of identity with known species rather than to that of giving new names. I may add, that the increase of my collection has enabled me to reunite many specimens which I had regarded as representatives of distinct species. But for the large number of specimens which I have been enabled to examine, I should certainly in the case of several variable species, as for example *Alethopteris lonchitica* and *Lepidodendron corrugatum*, have erred in this way. I am constantly more and more convinced that no satisfactory progress can be made in fossil botany without studying the plants as they occur in the beds in which they are found, or in large numbers of specimens collected from those beds, so as to ascertain the relation of their parts to each other.

DADOXYLON, Unger.

Large quantities of drifted coniferous trunks are found in the sandstones of the coal formation in Nova Scotia; but, after sliceing more than one hundred specimens, the following are the only species I can distinguish. It is to be observed, however, that the different states of preservation of these trunks render their study and comparison very difficult.

1. *Dadoxylon Acadianum*, s. n.

M. C. Joggin, Port Hood, Dorchester. J. W. D.;

Large trees, usually silicified or calcified, with very wide wood-cells, having three or more rows of small hexagonal areoles, each enclosing an oval pore; cells of medullary rays one-third of breadth of wood-cells, and consisting of twenty or more rows of cells superimposed in two series. Rings of growth indistinct.

2. *D. materiarium*, s. n.

M. and U. C. Joggins, Malagash, Pictou, &c., J. W. D. Glace Bay, H. Poole. Miramichi, G. F. Matthew.

Wood-cells less wide than those of the last; two to rarely four rows of hexagonal discs. Medullary rays very numerous, with twenty or more rows of cells superimposed in one series. Rings of growth slightly marked. Approaches in the character of its woody fibre to *D. Brandlingii;* but the medullary rays are much longer. Some specimens show a large sternbergia pith with transverse partitions.* Vast numbers of trunks of this species occur in some sandstones of the Upper Coal formation.

3. *D. antiquius*, s. n.

L. C. Horton, Dr. Harding.

Wood-cells narrow, thick-walled, two or three rows of pores, Medullary rays of three or four series of cells with twenty or more superimposed, nearly as wide as the wood-cells. Rings of growth visible. This species would belong to the genus *Palæoxylon* of Brongniart, and is closely allied to *D. Withami* L. and H., which like it occurs in the Lower Coal measures.

4. *D. annulatum*. s. n.

M. C. Joggins, Sir W. E. Logan. J. W. D.

Wood-cells with two or three rows of hexagonal discs. Medullary rays of twenty or more rows of cells superimposed, in two series. Wood divided into distinct concentric circles, alternating with layers of structureless coal representing cellular tissue or very dense wood. A stem six inches in diameter has fourteen to sixteen of these rings, and a pyritised pith about one inch in diameter. This is probably generically distinct from the preceding species.

ARAUCARITES, Unger.

Araucarites gracilis, s. n.

U. C. Tatamagouche., J. W. D.

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* Canadian Naturalist, 1857.

Branches slender, 0·2 inch in diameter, with scaly, broad leaf bases. Branchlets pinnate, numerous, very slender, wit small acute, spirally disposed leaves.

SIGILLARIA, Brongt.

Under this name I include four sub-genera, viz., (1). *Favularia* of Sternberg, of which *S. elegans* is the type; (2). *Rhytidolepis* of Sternberg, of which *S. scutellata* is the type; (3). *Sigillaria* proper, of which *S. reniformis* is the type; (4.) *Clathraria*, Brongt, of which *S. Menardi* is the type.

To these may perhaps be added *Asolanus* of Wood (Proc. Phila. Ac. Sci.), though most of the specimens of Sigillaria destitute of ribs are only portions of old trunks of the ribbed species. With these sub-genera I would place *Syringodendron* and *Calamodendron* as members of the gymnospermous family *Sigillariaceæ*. *Stigmaria* may be retained as a provisional genus, to include roots not connected with the trunks.

1. *Sigillaria* (*Favularia*) *eleyans*, Brongt.

M. C., Joggins, J. W. D.; Sydney, R. Brown: abundant, especially in the roofs of coal seams. *S. Hexagona* includes old trunks of this species. Young branches have scars of an elliptical form like those of *S. Serlii.*

2. S. (*Fav.*) *tessellata*, Brongt.

M. C., Joggins and Pictou, J. W. D.; Sydney, R. Brown.

3. *S.* (*Rhytidolepis*) *Scutellata*, Brongt.

M. and U. C., Joggins, Lyell, J. W. D.

4. *S.* (*Rh.*) *Schlotheimiana*, Brongt.

M. C. Joggins, Lyell, J. W. D.

5. *S.* (*Rh.*) *Saullii*, Brongt.

M. C. Sydney, R. Brown; Joggins, Lyell, J. W. D.

6. *S. Brownii*, Dawson (Jl. Geol. Socy., vol. X.)

M. C. Joggins, J. W. D.

7. *S. reniformis*, Brongt.

M. C. Joggins, Lyell, J. W. D., Sydney, R. Brown.

8. *S. levigata*, Brongt.

M. C. Sydney, R. Brown; Joggins, J. W. D.

9. *S. planicosta*, s. n.

M. C. Sydney, R. Brown.

Scars half hexagonal above, rounded below, lateral vascular impressions elongate, central small punctiform. Ribs $1\frac{1}{10}$ inch broad, smooth externally, longitudinally striate on ligneous surface. Slight transverse wrinkles between the scars, which are distant from each other about an inch. Allied to *S. levigata*, but with very thin bark.

10. *S. catenoides*, s. n.

M. C. Joggins, J. Smith. Sydney, R. Brown.

Cortical surface unknown, ligneous surface with puncto-striate ribs $1\frac{1}{10}$ inch in breadth and with single oval scars half an inch long, and an inch distant from centre to centre. A very large tree. Perhaps, if its cortical surface were known, it may prove to be a large *Syringodendron*.

11. *S. striata*, s. n.

M. C. Joggins, J. W. D.

Ribs prominent, coarsely striate, 0·35 inch wide. Scars nearly as wide as the ribs, rounded hexagonal, one inch distant; lateral vascular marks narrow, central large. On ligneous surface scars single, round, oblong; bark very thin.

12. *S.* ———

M. C. Joggins, J. W. D.

A small erect stem, somewhat like *S. flexuosa*.

13. *S.* (*Clathraria*) *Menardi*, Brongt.

M. C. Sydney, R. Brown; N. C. Pictou, J. W. D.

14. *S.* (*Asolanus*) *Sydnensis*, s. n.

M. C. Sydney, R. Brown.

Ribs obsolete; cortical and ligneous surfaces striate; vascular scars two, elongate longitudinally, and alike on cortical and ligneou surfaces; scars 1·1 inch distant, in rows 0·6 inch distant.

15. *S. organum*, L. and H.

M. C. Sydney, R. Brown.

16. *S. elongata*, Brongt.

M. C. Sydney, R. Brown.

17. *S. flexuosa*, L. and H.

M. C. Sydney, R. Brown's list, in Acadian Geology.

18. *S. pachyderma*, L. and H.

M. C. Sydney, R. Brown's list.

19. *S.* (*Fav.*) *Bretonensis*, s. n.

M. C. Sydney, R. Brown.

Like *S. tesseleata*, but areoles more hexagonal, bark thin and smooth on both sides, and furrow above the scars arcuate, and with a central punctiform elevation.

20. *S. eminens*, S. N.

M. C. Sydney, R. Brown.

Like *S obovata,* Lesqx. but with narrower ribs, and larger and less distant areoles, each with a slight groove above.

21. *S. Dournaisii*, Brongt.

M. C. Joggins, J. W. D.

22. *S. Knorrii*, Brongt.

M. C. Sydney, R. Brown.

SYRINGODENDRON, Brongt.

Obscure specimens, referrible to a narrow-ribbed species of this genus, occur in the lower carboniferous beds at Horton and Onslow.

STIGMARIA, Brongt.

Stigmaria ficoides, Brongt.

Under this name I place all the roots of *Sigillariæ* occurring in the carboniferous rocks of Nova Scotia. They belong, without doubt, to the different species of sigillaroid trees, but it is at present impossible to determine to which; and the specific characters of the Stigmariæ themselves are, as might be anticipated, evanescent and unsatisfactory. The varieties which occur in Nova Scotia, discarding mere differences of preservation, may be arranged as follows;

Variety (*a*) Areoles large, distant; bark more or less smooth. This is the most common variety, and extends throughout the coal formation.

" (*b*) Areoles large, separated by waving grooves of the bark.

" (*c*) similar, but ridges as well as furrows between the areoles; var. *undulata* of Göeppert.

" (*d*) Areoles small, separated by waving grooves.

" (*e*) Areoles moderate, in vertical or diagonal furrows separated by ridges; var. *sigillarioides* of Göeppert.

" (*f*) Areoles small, bark finely netted with wrinkles or striae.

" (*g*) Areoles surrounded by radiating marks, giving a star-like form; var; *stellata* of Göeppert. The only specimen I have seen was found by Dr. Harding in the lower carboniferous coal measures of Horton

" (*h*) Areoles small or obscure and unfrequent. Surface covered with fine uneven striae. My specimens were collected by Mr. Brown in the middle coal measures at Sydney

Variety (*i*) Areoles narrow, elongate, bark smooth or striate.

" (*k*) *alternans*, with areoles in double rows on broad ribs separated by deep furrows. Probably old furrowed roots.

" (*l*) *knorroides*, prominent bosses or ridges instead of areoles. These are imperfectly preserved specimens.

The varieties (*a*) (*b*) (*c*) (*e*) (*i*) have been seen attached to trunks of Sigillariæ of that group distinguished by broad and prominent ribs, *Sigillaria* proper of the above arrangement. Stigmariæ, like Sigillariæ, are exceedingly abundant in the middle coal measures, and are comparatively rare in the lower carboniferous and newer coal formations.

CALAMODENDRON, Brongt.

1. *Calamodendron approximatum*, Brongt.

M. C. Sydney, R. Brown; M. C. Joggins, Pictou, J. W. D.; Coal Creek, C. B. Matthew.

This plant is evidently quite distinct from *Calamites* proper. The calamite-like cast is a pith or internal cavity, surrounded by a thick cylinder of woody tissue consisting of scalariform vessels and woody fibres with one row of round pores; external to this is a bark of cellular and bast tissue. The structure appears to be allied to that of *Sigillaria*, and is one of the most common in the beds of bituminous coal.

2. *C. obscurum*, s. n.

M. C. Sydney, J. W. D.

This is a calamite-like fragment found in a block of Sydney coal, in the state of mineral charcoal. The external markings are obscure but the structure is well preserved. It differs from the last in having large ducts with many rows of pores, or reticulated, instead of scalariform vessels.

CYPERITES, L. and H.

Cyperites, ———

Middle and upper coals, everywhere.

These elongate linear leaves have two or three ribs and the central band between the ribs raised above the margin: one species has been seen attached to *Sigillaria Sclotheimiana*.

The leaves of *Sigillaria elegans* are different, being as broad as the areoles of the stem and with several parallel veins.

ANTHOLITHES, Brongt.

I include under this name spikes of inflorescence, or of fruits, usually showing buds or scaly floral leaves, and sometimes ovate fruits which may be young *Rhabdocarpi* or *Trigonocarpi*. I have not seen them attached to stems; but their associations would lead me to suppose that they may have belonged to *Sigillaria* or *Calamodendron*. Stems of Sigillaria of the groups *Rhytidolepis* and *Favularia* have rings of abnormal scars at intervals, which may have borne such spikes of fruit. No such marks are seen on the stems of other sub-genera of *Sigillaria*, which probably bore fruit at their summits.

1. *Antholithes rhabdocarpi*, s. n.

M. C. Grand L., C. F. Hartt.

Stem short, interruptedly striate, with two rows of crowded ovate fruit, and traces of floral leaves. Fruits half an inch long striate longitudinally, attached by short peduncles.

2. *A. pygmaea*, s. n.

M. C. Joggins, J. W. D.

Rhachis 1 inch thick, rugose; two rows of opposite flowers, each showing four lanceolate striate floral leaves, two outer and two inner.

3. *A. squamosa*, s. n.

U. C. Pictou, J. W. D.

Rhachis thick, coarsely rugose, with two rows of closely placed cones or scaly fruits.

4. *A.* ——— s. n.

M. C. Joggins, J. W. D; Sydney, R. Brown.

Indistinct, but apparently different from those above described.

TRIGONOCARPUM, Brongt.

1. *Trigonocarpum Hookeri*, Dawson. Geol. Journal, Vol, 17.

M. C. Mabou, J. W. D.

2. *T. Sigillariæ*, s. n.

M. C. Joggins, J. W. D. Ovate, ¼ inch long; testa smooth, or rugose longitudinally, acuminate, two-edged. Found in erect trunks of *Sigillariæ*, in large numbers.

3. *T. intermedium*, s. n.

M. C. Joggins, J. W. D. Allied to *T. olivæformis*, but larger and more elongated.

4. *T. avellanum*, s. n.

M. C. Joggins, J. W. D. Sydney, R. Brown.

Allied to *ovatum*, L. & H.; three-ribbed, size and form of a filbert.

5. *T. minus*, s. n.

M. C. Joggins, J. W. D. Half the size of *T. Hookeri*, and similar in form.

6. *T. rotundum*, s. n.

M. C. Joggins, J. W. D. Small, round ovate, slightly pointed.

7. *T. Nœggerathi*, Brongt.

Newer coal formation, Pictou, J. W. D.

The *Trigonocarpa* are very abundant in some beds of the Middle coal formation. Most of them are fruits of *Sigillariæ*, some of them perhaps of conifers.

RHABDOCARPUS, Goep. and Berg.

1. *Rhabdocarpus* ——— s. n.

M. C. Joggins, J. W. D. Ovate, acuminate, less than half an inch long.

2. *R. insignis*, s. n.

U. C. Pictou, J. W. D.; 1·5 inch long, ovate, smooth, with about 7 ribs on one side, and the intervening surface obscurely striate. The nature of this fossil is perhaps doubtful, but if a fruit it is the largest I have seen in the coal formation.

CALAMITES, Suckow.

1. *Calamites Suckowii*, Brongt.

M. C., Sydney, R. Brown; Joggins, Lyell, J. W. D.; Grand Lake, C. F. Hartt. U. C. Pictou, J. W. D. Coal Creek, C. B. Matthew.

This species is one of the most common in an erect position. It has verticillate branchlets with pinnate linear leaflets.

2. *C. Cistii*, Brongt.

M. C. Joggins, J. W. D.; Sydney, R. Brown; Grand Lake, C. F. Hartt; Bay de Chaleur, Logan. Coal Creek, C. B. Matthew.

Often found erect. Its leaves are verticillate, simple, linear, striate, apparently one-nerved and 3 inches long.

3. *C. cannæformis*, Brongt.

M. C., Joggins, Lyell, J. W. D.; Sydney, R. Brown.

4. *C. ramosus*, Artis.

M. C. Joggins, J. W. D. Sydney, R. Brown; possibly a variety of *C. Suckowii*.

5. *C. Voltzii*, Brongt—(irregularis, L. and H.)

M. C. Joggins, J. W. D.

Often erect. Has large irregular adventitious roots.

6 *C. dubius*, Artis.

M. C. Sydney, R. Brown; Joggins, J. W. D., Logan; U. C. Pictou, J. W. D.

7. *C. Nova Scotica*, s. n.

M. C. Joggins, J. W. D.

Ribs equal, less than a line wide, striate longitudinally. Joints obscurely marked and with circular areoles separated by the breadth of 3 to 4 ribs. Bark of moderate thickness.

8. *C. nodosus*, Schlot.

M. C. Sydney, R. Brown: Grand Lake, C. F. Hartt.

This species has long slender branchlets, with close whorls of short rigid leaves.

9. *C. arenaceous?* Jaeger.

This species is mentioned with doubt in Lyell's list.

EQUISETITES, Sternberg.

Equisetites curta, s. n.

M. C. Sydney, R. Brown.

Short thick stems, enlarging upward and truncate above, joints numerous, sheaths as long as the joints, with unequal acuminate keeled points. Lateral branches or fruit with longer leaf-like points. Has the characters of *Equisetites*, but its affinities are quite uncertain.

ASTEROPHYLLITES, Brongt.

1. *Asterophyllites foliosa*, L. and H.

M. C. Joggins, J. W. D; Sydney, R. Brown.

2. *A. equisetiformis*, L. and H.

M. C. Sydney, R. Brown; Pictou, J. W. D.

3. *A. grandis*, Sternberg.

M. C. Grand Lake, C. F. Hartt; Bay de Chaleur, Logan; Sydney, Bunbury.

The specimens resemble this species, but are not certainly the same. Logan's specimens have terminal spikes of fructification.

4. *A.* ———

A species with tubercles (fruit) in the axils is mentioned in Lyell's list as from Sydney. I have not seen it, but have a specimen from Mr. Brown similar to *A. tuberculata*, Sternberg, which may be the same.

5. *A. trinervis*, s. n.

M. C. Sydney, R. Brown.

Main stem smooth, delicately striate, with leaves at the nodes Branches delicately striate, with numerous whorls of linear nearly straight leaves, 0·5 inch long, twenty or more in a whorl, and showing two lateral nerves in addition to the median nerve. This and No. 2 would be placed by some authors in *Annularia*.

ANNULARIA, Sternberg.

Annularia galioides, Zenker.

M. C. Grand Lake, C. F. Hartt; U. C., Pictou, J. W. D.; Bay de Chaleur, Logan; Sydney, R. Brown.

SPHENOPHYLLUM, Brongt.

1. *Sphenophyllum emarginatum*, Brongt.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; Bay de Chaleur, Logan; Pictou, J. W, D.

2. *S. longifolium*, Germar.

U. C. Pictou, J. W. D., M. C. Sydney, R. Brown.

3. *S. Saxifragifolium*, Sternberg, Bay de Chaleur, Logan.

Elongate, much forked variety, closely allied to *S. bifurcatum* Lesquereux.

4. *S. Schlotheimii*, Brongt.

M. C. Sydney, Bunbury.

5. *S. erosum*, L. and H.

M. C. Sydney, Bunbury.

The two last species are regarded by Geinitz as varieties of *S. emarginatum*. A specimen of the last named species in Sir William Logan's collection shows a woody jointed stem like that of *Asterophyllites*, giving off branches at the joints. These again branch and bear whorls of leaves. The stem shows under the microscope a single bundle of reticulated or scalariform vessels like those of some ferns, and also like those of *Tmesipteris* as figured by Brongniart. This settles the affinities of these plants, as being with ferns or with *Lycopodiaceæ*.

PINNULARIA, L. and H.

1. *Pinnularia capillacea*, L. and H.

M. C. Sydney, R. Brown.

2. *P. ramosissima*, s. n.

M. C. Joggins, J. W. D. More slender and ramose than the last.

3. *P. crassa*, N. S..

L. C. Horton, C. F. Hartt. Branching like *P. capillacea* but much stronger and coarser.

All these are apparently branching fibrous stems or roots, of soft cellular tissue with a thin outer bark. Perhaps they are roots of *Asterophyllites*, or perhaps branchlets of an aquatic plant.

Genus Noeggerathia, Sternberg.

1. *Noeggerathia*——— ? s. n.

Bay de Chaleur, Sir W. E. Logan. A remarkable fragment of a leaf, with a petiole nearly three inches long, and a fourth of an inch wide, spreading abruptly into a lamina one side of which is much broader than the other, and with parallel veins running up directly from the margin as from a marginal rib. It appears to be doubled in at both edges, and is abruptly broken off. It seems to be a new species, but of what affinities it is impossible to decide.

2. *N. flabellata*, L. and H.

M. C. Sydney, R. Brown.

Cyclopteris. Brongt,

Including *Cyclopteris* proper and sub-genera *Aneimites* Dn. and *Nephropteris*, Brongt.

1. *Cyclopteris heterophylla*, Göeppert.

M. C. and U. C. Joggins, J. W. D.

2. *C.* (*Aneimites*) *Acadica*, Dawson, (Journ. Geol. Soc., Vol. 17.)

L. C. Horton, C. F. Hartt; Norton Creek, N.B., G. F. Matthew.

Stipe large, striate, branching dichotomously several times. Pinnæ with several broadly obovate pinnules grouped at the end of a slender petiolule, and with dichotomous radiating veins. Fertile pinnæ with recurved petiolules, and borne on the divisions of the main petiole near their origin. This plant might be placed in the genus *Adiantites*, Brongt., but for the fructification, which allies it with such ferns as *Aneimia*. It has a very large frond, the main petiole being sometimes three inches in diameter, and two feet long before branching. Flattened petioles have sometimes been mistaken for *Cordaites* and *Schizopteris*. It is a characteristic plant of the Lower coal measures.

3. *C. oblongifola*, Göeppert.

U. C. Pictou, J. W. D.

A little larger and coarser than Göeppert's figure.

4. *C.* (*Nephropteris*) *obliqua*, Brongt.

M. C. Sydney, R. Brown; Grand Lake, C. F. Hartt.

5. *C.* (*? Neuropteris*) *ingens*, L. & H.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt.

6. *C. oblata*, L. & H.

M. C. Sydney, R. Brown.

7. C. *fimbriata*, Lesquereux.

M. C. Sydney, R. Brown.

8. C. *hispida*, s. n.

M. C. Sydney, R. Brown.

Pinnate; pinnules obovate, diminishing in size toward the point, decurrent on the petiole, veins slender, distant, forking several times; under surface covered with stiff hairs.

NEUROPTERIS. Brongt.

1. *Neuropteris rarinervis*, Bunbury.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; Bay de Chaleur, Logan.

2. *N. perelegans*, s. n.

M. C. Sydney, R. Brown.

Resembles *N. elegans*, Brongt., but has narrower pinnules and nerves less oblique to the mid-rib.

3. *N. cordata*, Brongt. (and var. *angustifolia.*)

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

The ferns referred to this species are identical with *N. hirsuta* of Lesquereux. They abound in the Middle and Upper coal-formation, and have larger pinnules than any of our other ferns. A single terminal pinnule in my collection is five inches long. The surface is always more or less hairy.

4. *N. Voltzii*, Brongt.

N. C. Pictou, J. W. D.

A single imperfect specimen, like this species but uncertain.

5. *N. gigantea*, Sternb.

M. C. Sydney, R. Brown; Grand L., C. F. Hartt; U. C. Pictou, J. W. D.

6. *N. flexuosa*, Sternb.

M. C. Sydney, R. Brown; Joggins, J. W. D.

7. *N. heterophylla*, Brongt.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

9. *N. Loshii*, Brongt.

Bay de Chaleur, Logan.

10. *N. acutifolia*, Brongt.

M. C. Sydney, Lyell's list.

11 *N. conjugata*, Goept.

M. C. Sydney, Brown's list, Ac. Geol.

12 *N. attenuata*, L. & H.

M. C. Sydney, l. c.

13. *N. dentata*, Lesqx.

M. C. Sydney, R. Brown.

14 *N. Soretii*, Brongt.

M. C. Sydney, R. Brown.

15. *N. auriculata*, Brongt.

M. C. Sydney, R. Brown.

16. *N. Cyclopteroides*, s. n.

M. C. Sydney, R. Brown.

Pinnate; pinnules contiguous or overlapping, obliquely round-ovate, attached at the lower third of the base, nerves numerous, spreading from the point of attachment. Allied to *N. Villiersi* Brongt.

ODONTOPTERIS, Brongt.

1. *Odontopteris Schlotheimii*, Brongt.

M. C. Sydney, R. Brown; Bay de Chaleur, Logan; U. C. Pictou, J. W. D.

2. *O. antiqua*, s. n.

L. C.? Hebert R., J. W. D.

Tripinnate, petioles slender, pinnules oblong, obtuse, not contiguous. Terminal pinnules much elongated, venation obscure.

3. *O. Sub-cuneata*, Bunbury.

M. C. Sydney, R. Brown.

DICTYOPTERIS, Gutb.

Dictyopteris obliqua, Bunbury.

M. C. Sydney, R. Brown.

LONCHOPTERIS, Brongt.

Lonchopteris tenuis, s. n.

M. C. Sydney, R. Brown.

Pinnate or bipinnate, pinnules contiguous at base, nearly at right angles to petiole, oblong, elongate, obtuse. Network of veins very delicate. Allied to *L. Brierii*, Brongt., but with smaller more elongate pinnules and finer veins.

SPHENOPTERIS, Brongt.

1. *Sphenopteris munda*, s. n.

M. C. Grand Lake, C. F. Hartt.

Like *S. Dubuissonis*, Brongt., or *S. irregularis*, Sternberg, in habit; but the pinnules are obovate, decurrent and few-veined.

2. *S. hymenophylloides*, Brongt.

M. C. Sydney, R. Brown; U. C. Joggins, J. W. D.

3. *S. latior*, s. n.

M. C. Grand L., C. F. Hartt; U. C. Pictou, J. W. D.

Petiole forking at an obtuse angle, slender, tortuous, divisions bipinnate. Pinnæ with broad rounded confluent pinnules.

Veins twice forked, with Sori in the forks of the veins. In habit like *S. latifolia*, Brongt., and *S. Newburyi* and *S. squamosa*, Lesqx.

4. *S. decipiens*, Lesquereux.

M. C. Sydney, R. Brown.

5. *S. gracilis*, Brongt.

M. C. Joggins, J. W. D.; Grand L., C. F. Hartt.

6. *S. artemisifolia*, Brongt.

M. C. Grand L., C. F. Hartt; Sydney, R. Brown.

7. *S. Canadensis*, N. S.

Bay de Chaleur, Logan; Sydney? R. Brown.

General aspect like *S. Hoeninghausi*, but secondary pinnules with a margined petiole and oblong pinnules divided into five to three obtuse points. It is not unlike *S. marginata*, from the Devonian of St. John.

8. *S. Lesquereuxii*, Newberry.

M. C. Sydney, R. Brown.

9. *S. Microloba*, Guttbier.

M. C. Sydney, R. Brown.

10. *S. Obtusioloba*? Brongt.

M. C. Baie de Chaleur, Logan.

PHYLLOPTERIS, Brongt.

Phyllopteris antiqua, s. n.

M. C. Sydney, R. Brown.

Pinnate; petiole thick, woody, pinnules oblong, pointed, attached by middle of base; midrib strong extending to the point, giving off very oblique nerves which have obliquely pinnate nervules not anastomosing. A remarkable frond, which, if not the type of a new genus, must belong to that above named.

ALETHOPTERIS, Sternberg.

1. *Alethopteris lonchitica*, Sternberg.

M. & U. C. Joggins, J. W. D.; M. C., Sydney, R. Brown; Grand L., C. F. Hartt.

Very abundant throughout the Middle and Upper coal formation, and so variable that several species might easily be founded on detached specimens.

2. *A. heterophylla*, L. & H.

L. C. Parrsboro', A. Gesner.

3. *A. grandini*, Brongt.

M. C., Sydney, R. Brown

4. *A. nervosa,* Brongt.

M. C., Sydney, R. Brown; Bay de Chaleur, Logan; U. C., Pictou, J. W. D.

5. *A. muricata,* Brongt.

M. C., Joggins, Bathurst, Lyell; U. C., Pictou, J. W. D.

6. *A. pteroides,* Brongt. (*Brongnartii,* Göeppert.)

L. or M. C., Bathurst, Lyell's list.

7. *A. Serlii,* Brongt.

M. C., Sydney, R. Brown; Bay de Chaleur, Logan.

8. *A. grandis,* s. n.

Bay de Chaleur, Logan.

Bi-pinnate; pinnæ broad, contiguous, united at the base; veins numerous, once forked, not quite at right angles to the midrib. Upper pinnæ having the pinnules confluent so as to give crenate edges. Still higher the apex of the frond shows distant decurrent long pinnules with waved margins. A very large and fine species of the type of *A. Serlii* and *A. Grandini,* but much larger and different in details. Its texture seems to have have been membranaceous, and fragments from that part of the frond where the long simple pinnules are passing into the compound ones might be mistaken for an *Odontopteris.*

PECOPTERIS, Brongt.

1. *Pecopteris arborescens,* Schlot.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.; Wallace, Dr. Creed.

Seems to have been an herbaceous species with a very strong petiole. It occurs in an erect position in a sandstone on Wallace R.

2. *P. abbreviata,* Brongt.

M. C. Sydney, R. Brown; Salmon R., U. C., Pictou, J. W. D.

Very common both in the Upper and Middle coal formation.

3. *P. rigida,* s. n.

U. C. Pictou, J. W. D.

Similar to *arborescens,* but much smaller and with finer nerves.

4. *P. unita,* Brongt.

M. C. Sydney, R. Brown; U. C. Pictou, J. W. D.

Certain pinuules of a frond are sometimes swollen as if covered with fructification below; and in this state they resemble *P. arguta,* Brongt. The sori are seen in other specimens, and are large, round, and covered with an indusium as in *Aspidium.*

5. *P. plumosa*, Brongt.
M. C. Sydney, R. Brown.
6. *P. polymorpha*, Brongt.
M. C. Sydney, R. Brown.
7. *P. acuta*, Brongt.
M. C. Pictou, J. W. D.
8. *P. longifolia*, Brongt.
In Bunbury's list from Sydney.
9. *P. tæniopteroides*, Bunbury.
M. C. Sydney, R. Brown.
10. *P. cyathea*, Brongt.
M. C. Sydney, R. Brown.
11. *P. æqualis*, Brongt.
M. C. Sydney, R. Brown.
12. *P. Sillimani?* Brongt.
In Lyell's list from Sydney.
13. *P. villosa*, Brongt.
M. C. Pictou, Lyell's list.
14. *P. Bucklandii*, Brongt.
M. C. Sydney, Brown's list.
15. *P. oreopteroides*. Brongt.
M. C. Sydney, Brown's list.
16. *P. decurrens*, Lesqx.
M. C. Sydney, R. Brown; has pinnules more crowded, decreasing towards the apex., but may be a variety,
17. *P. Plunckenetii*, Sternb.
M. C. Sydney, R. Brown.

BEINERTIA, Göeppert.

Beinertia Göepperti, s. n.

M. C. Grand L., Hartt; Bay de Chaleur, Logan; U. C. Joggins, J. W. D.

Bi-pinnate, pinnæ broad, contiguous, obtuse, with thick pinnules. Pinnules above rounded, below obovate. Midrib thick, oblique, dividing above into a tuft of irregular hair-like veins.

HYMENOPHYLLITES, Göeppert.

Hymenophyllites pentadactyla, s. n.

M. C. Sydney, R. Brown. In general habit like *Sphenopteris microloba*, Göept, but with pinnules divided into 4 to 7 obtuse cuneate lobes, each with one vein.

PALÆOPTERIS, Geinitz.

1. *Palæopteris Hartii*, s. n.

M. C. Grand L., C. F. Hartt.

Stem or leaf bases transversely wrinkled with delicate lines, scars transversely oval, slightly appendaged below, vascular scars confluent. Breadth, 1.4 in. Length, 0.6 inch.

2. *P. Acadica*, s. n.

U. C. Pictou, J. W. D.

Stem or leaf bases longitudinally striated. Scars transverse, flat above, rounded and bluntly appendaged below; vascular scars in a transverse row; breadth of scars 0.7 inch; length 0.5 inch.

CAULOPTERIS, L. & H.

Several small erect stems at the Joggins seem to be trunks of ferns but are too obscure for description.

PSARONIUS, Cotta.

Trunks of this kind must be rare in the Nova Scotia coal fields. A few obscure stems surrounded by cord-like aerial roots have been found, and probably are remains of plants of this genus.

MEGAPHYTON, Artis.

1. *Megaphyton magnificum*, s. n.

M. C. Joggins, J. W. D.

Stems large, roughly striate longitudinally; scars contiguous, orbicular, deeply sunk, nearly three inches in diameter, and each with a bilobate vascular impression, two inches broad and an inch high.

2. *M. humile*, S. N.

M. C. Sydney, R. Brown.

Stem 2·5 inches in diameter; leaf scars prominent, flattened and broken at the ends, 1 inch wide. Surface of the stem marked with irregular furrows and invested with a carbonaceous coating. An internal axis nearly two inches in diameter, with a coaly coating, sends off obliquely thick branches to the leaf scars. This is a very remarkable specimen, and throws much light on the structure of *Megaphyton*. Unfortunately the minute structures are not preserved.

Genus LEPIDODENDRON, Sternberg.

1. *Lepidodendron corrugatum*, Dawson. Journal Geol. Society, Vol. XV.

L. C. Horton, C. F. Hartt, J. W. D.; Norton Creek, &c., N. Brunswick, G. F. Matthew.

Areoles elongate, ovate, acute at both ends, with a ridge along the middle, terminating in a single elevated vascular scar at the upper end. In certain states the vascular mark appears in the middle of the areole. In young branches the areoles are contiguous and resemble those of *L. elegans.* In old stems they become separated by spaces of longitudinally wrinkled bark ; in very old stems these spaces are much wider than the areoles.

Leaves linear, one inch or more in length, usually reflected, one-nerved.

Cones (Lepidostrobi) terminal, short cylindric, with numerous short acute triangular scales.

Structure of stem—a central pith with a slender cylinder of scalariform vessels, exterior to which is a thick cylinder of cellular tissue and bast fibres, and a dense outer bark.

Variety *verticillatum* has the areoles arranged in regular decussate whorls instead of spirally. This difference, which might at first sight seem to warrant even a generic distinction, is proved by specimens in my possession to be merely a variety of phyllotaxis.

This species is eminently characteristic of the Lower carboniferous coal measures; and has not yet been found in the Middle coal formation. Fragments of bark resembling that of this species occur in the coal formation of Bay de Chaleur, along with leafy branches of *Lepidodendron*, which resemble those of this species, though I believe distinct.

2. *L. Pictoense*, s. n.

M. C. Sydney, R. Brown; Pictou, H. Poole and J. W. D.; Grand Lake, C. F. Hartt.

Areoles contiguous, prominent, separated in young stems by a narrow line, long oval, acuminate, breadth to length as 1 to 3 or less, lower half obliquely wrinkled, especially at one side. Middle line indistinct. Leaf scar at upper end of areole, small, triangular, with traces of three vascular points, nearly confluent. Length of areole about 0.5 inch.

Leaves contracted at base, widening slightly and gradually contracting to a point, ribs three, central distinct, lateral obscure, length 1 inch.

Cones borne on sides of smaller branches, small, oval, obscurely scaly.

In habit of growth this species resembles *L. elegans*, for which imperfect specimens might be mistaken. It abounds in the Middle coal measures.

3. *L. rimosum*, Sternberg.

M. C. Sydney, R. Brown ; Joggins, J. W. D.

4. *L. dichotomum*, Sternberg, (*L. Sternbergii*, L. & H.)

M. C. Sydney, R. Brown ; Joggins, J. W. D. ; L. C. Horton, J. W. D.

5. *L. decurtatum*, s. n.

M. C. Pictou, J. W. D.

Areoles approximate or separated by a shallow furrow, rhombic, ovate, obliquely acuminate below, nearly as broad as long, wrinkled transversely, especially on the middle line, which appears tuberculated, vascular scar rhombic, twice as broad as long, with three approximate vascular points. In some flattened specimens the line separating the areoles is indistinct, and the scars appear on a transversely wrinkled surface without distinct areoles.

6. *L. undulatum*, Sternberg.

M. C. Sydney, R. Brown, Joggins and Pictou, J. W. D. ; U. C. Joggins, J. W. D.

Possibly several species are included under this name, but they cannot be separated at present.

7. *L. dilatatum*, Lindley and Hutton.

M. C. Joggins, J. W. D.

8. *L.* ——— like *tetragonum*, Göept.

L. C. Horton, J. W. D.

Obscurely marked, but a distinct species, unless an imperfectly preserved variety of *L. tetragonum*. The areoles are square with a rhombic scar at the upper corner of each.

9. *L. binerve*, Bunbury.

M. C. Sydney, R. Brown.

10. *L. tumidum*, Bunbury.

M. C. Sydney, R. Brown.

I think it probable that this species belongs to the genus *Lepidophloios*, but I have not seen a specimen.

11. *L. gracile*, Brongt.

M. C. Sydney, R. Brown.

In Brown's list in Ac. Geology. Probably a variety of the next.

12. *L. elegans*, Brongt.

M. C. Sydney, R. Brown.

In Bunbury's and Brown's Lists.

13. *L. plumarium*, L. and H.

M. C. Sydney. In Brown's List.

14. *L. selaginoides*, Sternb.

M. C. Sydney. In Brown's list.

15. *L. Harcourtii*, (Witham.)

M. C. Sydney. In Brown's list.

16. *L. clypeatum ?* Lesqx.

M. C. Sydney, R. Brown; U. C., Joggins, J. W. D.

17. *L. aculeatum*, Sternberg.

M. C. Sydney, R. Brown.

HALONIA. L. & H.

Halonia ?———

A specimen probably referrible to this genus from Grand Lake, in the collection of C. F. Hartt.

LEPIDOSTROBUS. Brongt.

1. *Lepidostrobus variabilis*, L. & H.

M. C. Sydney, R. Brown; Pictou and Joggins, J. W. D.

The most common species.

2. *L. squamosus*, s. n.

M. C. Grand Lake, C. F. Hartt.

Two to three inches long, 1 inch thick, scales large, broadly trigonal, acute. Allied to No 6, but larger.

3. *L. longifolius*, s. n.

Long-leaved like *Lepidodendron longifolium*, L. and H.

Middle Coal-formation, Joggins, J. W. D.

4, *L.*———

Acute trigonal leaves, small.

Middle Coal-formation, Joggins, J. W. D.

5. *L.*———

Round with obscure scales and remains of long leaves.

Lower Coal Measures, Horton, J. W. D.

6. *L. trigonolepis*, Bunbury.

M. C. Sydney, R. Brown.

LEPIDOPHYLLUM. Brongt.

1. *Lepidophyllum lanceolatum*, L. & H.

M. C. Joggins; U. C. Pictou, J. W. D

2. *L. trinerve ?* L. & H.

U. C. Joggins, J. W. D.

Two-nerved or three-nerved like *L. trinerve*, L. & H. but narrower. Both th above are parts of *Lepidostrobi.*

3. *L. majus?* Brongt.

M. C. Sydney, R. Brown.

4. *L.*———

Broad ovate, short, pointed, one nerved, half an inch long.

Upper coal formation, Pictou.

5. *L. intermedium*, L. & H.

M. C. Sydney, R. Brown's list.

Halonia, Lepidostrobus and Lepidophyllum, including only parts of *Lepidodendron and Lepidophloios*, are to be regarded as merely provisional genera.

LEPIDOPHLOIOS, Sternberg.

Under this genus I include, on the evidence of numerous specimens, those plants known under the names *Ulodendron*, L. & H., *Bothrodendron*, L. & H., and *Lomatofloyos*, Corda, and in part *Halonia, Lepidostrobus* and *Lepidophyllum.* These trees have more or less elevated areoles or leaf-bases, rhombic in outline, and terminated by rhombic scars, bearing long, narrow, one-nerved leaves. The fruit consists of large strobiles borne on the sides of the stem and branches. The internal structure presents a large cellular pith, a slender cylinder of scalariform vessels, a very thick cellular and corky bark, and a dense rind or epidermis. They appear to have branched seldom and dichotomously, and are nearly related to *Lepidodendron.* They are abundant in the Middle coal formation.

1. *Lepidophloios Acadianus*, s. n.

M. C. Joggins, Salmon, R., Pictou, J. W. D.; Sydney, R. Brown.

Leaf-bases broadly rhombic or in old stems regularly rhombic prominent, ascending, terminated by very broad rhombic scars having a central point, and two lateral obscure points. Outer bark laminated or scaly. Surface of inner bark with single points or depressions. Leaves long, linear, with a strong keel on one side five inches or more in length, cone-scars sparsely scattered on thick branches, either in two rows or spirally, both modes being sometimes seen on the same branch. Scalariform axis scarcely an inch in diameter in a stem five inches thick. Fruit, an ovate strobile with numerous acute scales covering small globular spore cases. This species is closely allied to *Ulodendron majus* and *Lepidophloios laricinum*, and presents numerous varieties of marking.

2. *L. prominulus*, s. n.

M. C. Joggins, J. W. D.

Leaf-bases rhombic, pyramidal, somewhat wrinkled at the sides, truncated by regularly rhombic scars, each with three appproximate vascular points.

3. *L. parvus*, s. n.

U. C. Pictou; M. C. Joggins, J. W. D.; M. C. Sydney, R. Brown

Leaf-bases rhombic, small, with rhombic scars broader than long, vascular points obscure. Leaves linear, acute, three inches or more in length, with a keel and two faint lateral ribs. Cones large, sessile.

4. *L. platystigma*, s. n.

M. C. Sydney, R. Brown; Joggins, J. W. D.

Leaf-bases rhombic, broader than long, little prominent. Scars rhombic, oval, acuminate, slightly emarginate above, vascular points two, approximate or confluent.

5. *L. tetragonus*, s. n.

M. C. Joggins, J. W. D.

Leaf-bases square, furrowed on the sides. Leaf scar central with apparently a single central vascular point.

Diplotegium, Corda.

Diplotegium retusum, s. n.

M. C. Joggins, J. W. D.

The fragments referrible to plants of this genus are imperfect and obscure. The most distinct show leaf bases ascending obliquely, and terminating by a retuse end with a papilla in the notch. Some less distinct fragments may possibly be imperfectly preserved specimens of *Lepidodendron* or *Lepidophloios*.

Knorria.

Nearly all the plants referred to this genus, in the carboniferous rocks are, as Göeppert has shown, imperfectly preserved stems of *Lepidodendron*. In the Lower coal formation many such knorria forms are afforded by *L. corrugatum*.

Knorria Sellonii, Sternberg.

M. C. Sydney, R. Brown.

This appears different from the ordinary *Knorriæ*. Its supposed leaves may be aërial roots. It has a large pith cylinder with very distant tabular floors like Sternbergia.

Cordaites, Unger, (*Pycnophyllum*, Brongt.)

1. *Cordaites borassifolia*, Corda.

M. C. Pictou, H. Poole; Grand L., C. F. Hartt,; Sydney, R.

Brown; Joggins, Onslow, J. W. D.; Bay de Chaleur, Logan. Very abundant in the Middle coal formation.

2. *C. simplex*, s. n.

M. C. Grand R., C. F. Hartt; U. C. Pictou: J. W. D.

Leaves similar to the last in size and form, but with simple equal parallel nerves. It may be a variety; but is characteristic of the Upper coal formation.

CARDIOCARPUM, Brongt.

1. *Cardiocarpum fluitans*, s. n.

M. C. Joggins, J. W. D.

Oval, apex entire or notched. Surface slightly rugose. Nucleus round ovate, acuminate, pitted on the surface, with a raised mesial line.

2. *C. bisectatum*, s. n.

M C. Grand Lake, C. F. Hartt.

Nucleus as in the last species, but striate. Margin widely notched at apex, and more narrowly notched below.

3. *C.* like *marginatum.*

M. C. Joggins, J. W. D.

4. *C.* Allied to *C. latum*, Newberry.

M. C. Pictou, H. Poole.

These Cardiocarpa are excessively abundant in the roofs of some coal seams; and the typical ones must have been samaras or winged nutlets. They must have belonged to phaenogamous plants, and certainly are not the fruits of *Lepidodendron*, though some of the spore-cases of this genus have been described as *Cardiocarpa.* These I propose to place under the provisional genus *Sporangites.*

SPORANGITES, Dawson.

1. *Sporangites papillata*, s. n.

M. C. Joggins, J. W. D.

I propose the provisional generic name of *Sporangites* for spores or spore cases of *Lepidodendron*, *Calamites* and similar plants, not referred to the species to which they belong. The present species is round, about one inch in diameter, and covered with minute raised papillæ or spines. It abounds in the roof of several of the shaly coals in the Joggins section, and especially in one in group XIX of that section.

2. *S. Glabra*, s. n.

About the size of a mustard seed, round and smooth. Exceedingly abundant in the lower carboniferous coal measures of Horton Bluff, with *Lepidodendron corrugatum*, to which it possibly belongs. A similar spore-case, possibly of another species of *Lepidodendron*, occurs rarely in the Middle coal formation at the Joggins.

STERNBERGIA, Artis.

This provisional genus includes the piths of *Dadoxylon*, *Sigillaria*, and other plants, usually preserved as casts in sandstone, retaining more or less perfectly the transverse partitions into which the pith-cylinders of many coal-formation trees became divided in the process of growth. These fossils are most abundant in the Upper coal formation, but occur also in the Middle coal formation. The following varieties may be distinguished :

(*a*) Var. *approximata*, with fine uniform transverse wrinkles. This is usually invested with a thin coating of structureless coal.

(*b*) Var. *angularis*, with coarser and more angular transverse wrinkles. This is the character of the pith of Dadoxylon.

(*c*) Var. *distans*, usually of small size, and with distant and irregular wrinkles. This is sometimes invested with wood having the structure of *Calamodendron*, and perhaps is not generically distinct from *C. approximatum*.

(*d*) Var. *obscura*, with distinct and distant transverse wrinkles, but not strongly marked on the surface. This is the character of the pith cylinders of *Sigillaria* and *Lepidophloios*.

ENDOGENITES, L. & H.

Many sandstone casts, answering to the character of the plants described under this name by Lindley, occur in the Upper coal formation. They are sometimes three inches in diameter and several feet in length, irregularly striate longitudinally, and invested with coaly matter. Sometimes they show transverse striation in parts of their length. I believe they are casts of pith cylinders of the nature of *Sternbergia*, and probably of sigillaroid trees.

SOLENITES, L. & H.

Plants of this kind are found in the sandstones of the Upper coal formation of the Joggins.

For all the specimens noted in the above list, as collected by Sir W. E. Logan, Richard Brown, Esq., of Sydney, Cape Breton, Henry Poole, Esq., of Glace Bay, C. B., and G. F. and C. B. Matthew and C. F. Hartt, Esqs., St. John, New Brunswick, I am indebted to the kindness of those gentlemen. To Mr. Brown especially I am under great obligations for his liberality in placing at my disposal his large and valuable collection of the plants of the Cape Breton coal field.

The general conclusions deducible from the above catalogue, as well as detailed descriptions of the new species, I hope to give more fully hereafter, when I shall have completed my examination of the microscopic structure of the several coal seams. In the mean time the following summary may be useful :

1. Of 192 nominal species in the list, probably 44 may be rejected as founded merely on parts of plants, leaving about 148 true species.

2 Of these, on comparison with the lists of Unger, Morris, and Lesquereux, 92 seem to be common to Nova Scotia and to Europe, and 59 to Nova Scotia and the United States. Most of these last are common to Europe and the United States. There are 50 species peculiar, in so far as known, to Nova Scotia, though there can be little doubt that several of these will be found elsewhere. It would thus appear that the coal flora of Nova Scotia is more closely related to that of Europe than to that of the United States, a curious circumstance in connection with the similar relationship of the marine fauna of the period ; but additional information may modify this view.

2. The greater part of the species have their head-quarters in the Middle coal formation, and scarcely any species appear in the Upper coal formation that are not also found in the former. The Lower coal formation on the other hand seems to have a few peculiar species not found at higher levels.

3. The characteristic species of the Lower coal formation are *Lepidodendron corrugatum* and *Cyclopteris Acadica*, both of which seem to be widely distributed at or near this horizon in Eastern America, while neither has yet been recognized in the true or Middle coal measures. In the Upper coal formation *Calamites Sucks owii, Annularia galioides, Sphenophyllum emarginatum, Cordaite- simplex, Alethopteris nervosa, muricata etc., Pecopteris arborescens, P. abbreviata, P. rigida, Neuropteris cordata, Dadoxylon materiarum, Lepidophloios parvus, Sigillaria scutellata*, are characteristic plants, though not confined to this group.

4. In the Middle coal formation and in the central part of it, near the greater coal seams, occur the large majority of the species

of *Sigillaria*, *Calamites*, *Lepidodendron* and *Ferns;* some of the species ranging from the Millstone grit into the Upper coal formation, while others seem to be more narrowly limited. It is to be observed, however, that as we leave the central part of the system, the total number of species diminishes both above and below, and that it is only in those beds which hold large numbers of plants *in situ* or nearly so, that we can expect to find a great variety of species, and especially the more delicate and perishable organisms.

It is also quite observable in the Joggins section that while some beds, in the same part of the system, supported *Sigillariæ*, others carried *Calamites*, others mixtures of these with other plants; so that differences of soil, moisture, etc., frequently cause neighbouring beds to be more dissimilar in their fossil contents than others much more widely separated. These local and temporary differences must always have occurred in the deposition of the coal measures, and should not be confounded with those general changes which are connected with lapse of time.

ART. XXXI—*On the Origin of Eruptive and Primary Rocks;* by THOMAS MACFARLANE. *Part III.*

III. THE PRIMARY FORMATION.

Following out the plan indicated in the first part of this paper, we proceed to the consideration of the primary rocks, with the view of ascertaining whether they, in part at least, may reasonably be regarded as constituting the first solidified crust of the earth. The igneous condition of the original globe has already been adverted to, and it would seem unnecessary here to refer at length to what may be called the keystone of this theory, viz. the flattening of the earth at the poles. It is sufficient to remark on this point, that Newton and Huygens first maintained and proved this to be the case, from mathematical grounds alone. Subsequently numerous measurements of the length of a degree in various lands, but especially in those near the equator and under the polar circle, have thoroughly established the truth of Newton's theory. They have proved that the length of a degree of latitude increases with the distance from the equator. The following are some of the results obtained:

	Latitude.	Length of degree of Latitude.
Peru	1°31	56736.8 toises.
India	12°32	56762.3 "
France	46°8	57024.6 "
England	52°2	57066.1 "
Lapland	62°20	57196.2 " *

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* Muller's Kosmische Physik, p. 51.

The meridian lines are therefore more considerably curved in the neighbourhood of the equator than at the poles, and the equatorial diameter of the earth is consequently greater by about 24 geographical miles than the polar diameter. This is of course, a consequence of the revolution of the earth on its axis, and of the influence of centrifugal force. This influence could not, however, have made itself felt, had not the earth been originally in a fluid, or at least plastic condition, so that the depression at the poles constitutes one of the most unequivocal proofs of the original fluid condition of the globe.

Assuming this fluid condition to have been owing to the prevalence of an extremely high temperature, we are necessitated to suppose that the atmosphere was then very differently constituted than it is at present. This has been remarked by many previous writers. Dr. Hunt describes it as 'an atmosphere holding in the state of acid gases all the carbon, the sulphur and the chlorine, besides the elements of air and water."* Quensted remarks: "According to the igneous theory the whole of the siliceous rocks were originally in lava-like fusion. It follows of course that not only the whole of the sea must have existed in the atmosphere. but also a multitude of substances, which could not exist otherwise than in the gaseous state, such as carbonic acid, chlorine, sulphur, etc."† These inferences are legitimately drawn. The sandstones, shales, and the fixed parts of the limestones of sedimentary formations then existed in the fused matter, along with the materials of the igneous and primary rocks, the soda of sea-salt and the inorganic constituents of plants and animals. On the other hand, the carbonic acid of the limestones must have existed in the atmosphere. The chlorine of the sea salt also could scarcely have existed anywhere else than in the atmosphere in combination with hydrogen, or with those metals which form with it volatile chlorides, such as lead, zinc, copper, iron, cobalt, nickel, etc. Those volatile chlorides, which are decomposable while in the gaseous state by oxygen, (such as those of the three metals last named) could not however have existed in an atmosphere containing free oxygen, but it would seem, that the primitive atmosphere did not contain any such free oxygen. Bischof first adopted this view. He maintains that the carbon disseminated through the dark clay slates of the pre-carboniferous periods, is in itself more than sufficient to take up all the oxygen which the atmosphere of the present day contains.* He calculates also that a stratum of carbon, spread over the whole surface of the globe, 2.6 feet thick, would be sufficient to convert all the oxygen of the atmosphere into carbonic acid; and after considering how richly furnished the sea is with animal and vegetable life, how rich its sedimentary deposits must be in organic substances; that the earlier sedimentary rocks are highly changed with carbonaceous and bituminous substances, that beds of coal and lignite are spread over an area of many hundreds of square miles with a very considerable average thickness, he comes to the conclusion, that a layer 2.6 feet thick is far from being an equivalent to all the carbon existing in the earth, leaving altogether out of the question the carbon of the organic world on its surface. This opinion certainly seems to be well grounded, and there would appear to be just reason for supposing that the oxygen of the atmosphere existed originally in the state of carbonic acid, and that a considerable quantity of carbon, besides that which was in combination with the oxygen, must have existed in the original atmosphere, either free, or in combination with other elements, and probably especially with hydrogen. Thus the gaseous envelope of the original globe must have been an enormous atmosphere of water, carbonic acid, carburetted hydrogen, and nitrogen, together with comparatively small quantities of sulphurous acid, and sulphuretted hydrogen, hydrochloric acid and metallic chlorides. The pressure of such an atmosphere must have been prodigious, at least 100 times greater than that of the present time; and in conjunction with its composition sufficient to produce effects totally different from those caused by atmospheric influences at the present day. Among its most remarkable properties must have been its power of absorbing heat. Dr. Hunt has shown that the atmosphere of paleozoic times must, from the amount of carbonic acid in it, have greatly aided to produce the elevated temperature then existing.† How much more must this have been the case when the atmosphere contained such hydro carbons as marsh and olefiant gases, whose power of absorbing radiant heat greatly exceeds that of carbonic acid.‡ Dr. Hunt has indeed indicated the part which such hydrocarbons may thus have played. After the fluid globe had sufficently cooled, to allow the condensation of some of the constituents of this primitive atmosphere, the action of these on the earth's crust must have been very energetic, and must have caused the formation of products differing considerably from the sedimentary deposits of later periods. We shall return to this subject, when adverting to the rocks of the so-called Primitive Slate formation.

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* Canadian Naturalist, p. 202.

† Epochen der Natur. p. 20.

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* Chem. and Phys. Geologie, ii. p. 35.

† Canadian Naturalist, vol. viii. p. 324.

‡ Tyndal: Heat considered as a mode of motion, p. 362.

With regard to the fluid part of the original globe, we have seen that it must have been made up, with but little exception, of the inorganic constituents of the earth's crust. It is evident, that in this fluid globe the heavier particles must have found their way to the centre, and that then, as now, the interior of the globe must have had a greater density than its surface. Indeed, the fact that this is the case at the present day is another proof that the globe must have been originally in a state of igneous fluidity, otherwise we could not account for the accumulation of the denser particles at the centre. In the same way as the densest particles were influenced by gravitation, so must also the fused silicates of different densities, and the metallic sulphurets and arseniurets have found their places in successive concentric zones, one beneath the other, according to their increasing specific gravities. Thus the theory of Sartorius von Waltershausen would appear to be as fully applicable when the earth was in a fluid state, as at the present time.

There is nothing unreasonable or inconsistent with the observations which we are able to make at the present day, in supposing the inorganic constituents of the earth to have once been in a state of igneous fusion. The various layers of fused material, to judge from the rocks resulting from their solidification, must have close-resembled in chemical composition the scoriæ produced in different blast-furnaces. If we suppose the uppermost highly silicified and consequently most difficultly fusible layer to be represented by granite, we find many instances of slags from iron-furnaces having almost as acid a composition. Many granites contain only 63 per cent. of silica, but those of the Hartz as high as 73.* On the other hand there are instances of iron-slags containing 70 and 71 per cent.† silica. So far as the other more basic layers and the rocks resulting from them are concerned, we can find their equivalents among the slags of iron, copper and lead furnaces, since the silica contents of the latter range from 70 through every percentage down to 8 p.c. If we continue the analogy, and suppose the properties of these slags, to correspond somewhat to those of the eruptive rocks having a similar chemical composition, we may find a clue to the explanation of the various forms of deposition, and other characteristics of the latter. Thus it is well known that the slags in which silica preponderates flow sluggishly and solidify slowly, while basic slags flow quick and hot and harden suddenly. It may reasonably be concluded, that the rocks of igneous origin would act similarly, and that consequently granites, porphyries and trachytes would be more viscid, and have better time for cooling and crystallizing, than the more basic greenstones, melaphyres and basalts. The greater frequency of impalpable and finely granular varieties among the latter rocks would be in this way accounted for.

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* Bischof: Chemical and Physical Geology, III. p. 414.

† Kerl: Handbuch der Hûttenkunde, I. p. 323.

We now proceed to consider what must have been the consequence of the gradual radiation of heat from the igneous globe. "I know of no mode," says McCulloch,* "in which the surface of a fluid globe could be consolidated but by radiation, while of the necessity of such a process I need not again speak. The immediate result of this must have been the formation of rocks on that surface; and if the interior fluid does now produce the several unstratified rocks, the first that were formed must have resembled some of these, if not all. We may not unsafely infer that they were granitic, perceiving that substances of this character have been produced wherever the cooling appears to have been most gradual. The first apparently solid globe was therefore a globe of granite, or of those rocks which bear the nearest crystalline analogies to it." To these utterances we must in the main assent, inquiring however whether the relations existing at the time of this first solidification might not have given rise to the formation of schistose granite or gneiss. Nothing is more conclusively established, than that there exists, at the present day, in the atmosphere and ocean, a series of currents, caused by or attributable to the diurnal motion of the earth. May not similar currents have been in operation in the fluid igneous material, during the first solidification of the earth's crust? Is it not possible that after this solidification had commenced, the outer shell may have moved quicker than the fluid interior, from east to west, and that the gradual accumulation of crystallized rock on the interior of the crust may have taken place under circumstances similar to those so well described by Naumann in referring to the parallel structure of certain igneous rocks?* There are not wanting instances of the formation of a slaty structure in artificially formed slags, from a similar cause. Nothing is more common than to observe in slags from iron-furnaces a distinct streaked or banded appearance, evidently caused by the different rate of motion in the interior and outside parts of the flowing stream of slag. This phenomenon I have often observed at the Eglinton iron-works, Scotland, and more recently at Bethlehem, Pennsylvania. It is simply another instance of the production of a stratified appearance, similar to those described by Tyndall in his work "On the Glaciers of the Alps." In this work he shows that the banded appearance of glacier-ice, the lamination of wax subjected to pressure, and the fibrous texture of rolled iron, are caused by the motion under pressure of the atoms constituting those substances. Not only has a banded structure been observed among certain furnace scoriæ, but the latter have even been observed to possess sometimes both fibrous and foliated structures. The raw slag from the "Frischfeuer" at Bieber in Hessia, possesses a marked fibrous texture, and slag with a distinct slaty texture is produced at the blast-furnace in Mâgdesprung. The latter is formed swimming on melted iron, while its surface comes in contact with the cold air. Small pieces of this slag resemble the refuse of roofing slate, not only in their appearance, but also in their cleavage. In larger pieces perfectly vitreous layers are combined with the slaty ones, both graduating into each other.† From these instances, and considering that the existence of internal currents at that period is highly probable, it would appear not unreasonable to expect that some of the rocks solidified on the surface of the fluid globe, would have a schistose structure. It is impossible to suppose that the particles of the fluid material beneath the solidifying crust, would always preserve the same relative position to the latter, in spite of the daily revolution of the globe. The liquid rock beneath the crust must have moved in one direction or other almost as freely as the water of a frozen river under the ice which covers it. The schistose structure resulting from this solidification under motion must however have resembled more the foliation of certain igneous rocks than the stratification of sedimentary strata. The stratification of gneiss and gneissoid rocks has not unfrequently been denied. Thus Featherstonhaugh declared, that "what has been called the stratification of these igneous rocks, may be owing to the principle which occasions their fissility." Coquand regards gneiss as a "granite stratoïde, mais non stratifié."* Rivière opines also that gneiss does not form true layers, but is only a fissile or pseudo-stratified rock.† Even McCulloch makes the following admission: "Gneiss has not yet indeed presented any decided marks of that mechanical arrangement which so often occurs in the other stratified rocks; since I must explain the parallelism of the mica, which has been supposed a proof of such arrangements, in a very different way. In hypersthene rock, an unstratified member of the trap family, the crystals of that mineral often occur in a similar laminar manner, so as to communicate a fissile tendency to it; and in Kerrara mica itself is thus found not only in a mass of trap, but in a vein of the same substance, with the same parallelism to the sides of the vein as it has to the plane of the stratum in micaceous schist."‡ The idea that gneiss may have been formed in the manner above indicated is not entirely new. In 1845 it was stated that the gneiss of the Saxon Erzgebirge "perhaps differs only from granite because it solidified under the influence of certain pressures or tensions.‖

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* System of Geology, vol. ii. p. 417.

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* Canadian Naturalist, vol. viii. p. 375.

† Von Leonhard, Hüttenerzeugnisse und andere auf künstlichem Wege gebildete Mineralien als Stützpunkte geologischer Hypothesen, p. 156.

Whether the explanation here attempted of the parallel structure of gneiss may be regarded as adequate or not, it does not at any rate seem to be any more far-fetched than the theory which attributes this phenomenon to the influence of electrio magnetic currents (Scheerer's theory) or even than that which regards gneiss as a sedimentary rock, altered in some obscure manner by heat or other agencies. Besides the arguments given above in support of the first mentioned view, there are also some general considerations in favor of the existence of a primitive formation, which are stated as follows by Naumann.§ "The oldest sedimentary formations must have had some material from which they could be formed, and a foundation on which to be deposited. The whole series of sedimentary formations must have been borne by something, and the material of at least the first member of this series must have been derived from something, which something cannot be assumed to be the result of a sedimentary operation."

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* Bull. de la Soc. Geol. tome ix. 1838, p. 222.

† Compte rendus, tome xxv. 1847, p. 898.

‡ System of Geology, Vol. II. p. 152.

‖ Geognostische Beschreibung des Königreiches Sachsen, 2tes Heft, p. 122.

§ Lehrbuch der Geognosie, ii., p. 8.

"In the same way there must have existed a covering through which the oldest eruptive formations were protruded, and a foundation upon which they could spread themselves out; and the whole series of eruptive rocks must, like those of sedimentary origin, have at the commencement been borne by something which cannot be regarded as the result of an eruptive operation."

"We find ourselves thus obliged, from two sides, to assume the existence of an originally existing solid crust of the planet, which formed the theatre and the foundation for all the later formations, above and beneath which those two energies in nature could develop themselves; through which on the one side the sedimentary, and on the other side the eruptive formations were brought into existence; and that formation of which this original foundation consisted it is consequently proper to entitle the primitive or themelian, the original or fundamental formation."

"To this formation those enigmatical, deepest-lying rocks belong which resemble sedimentary strata, in possessing more or less perfect stratification, and which resemble eruptive rocks, when their mineral composition and their crystalline structure are taken into consideration; but they are devoid of the fragmentary rocks and the organic remains by which the sedimentary formations are characterized, and on the other hand do not possess the veins, masses and streams common to eruptive rocks, nor the abnormal relations of these at their junction with other rocks. In a word, we meet in the primitive formation many of those rocks which we have above designated cryptogenous, such as gneiss, mica-schist, hornblende-schist, etc.; rocks whose unaltered character we are not justified in denying in every case, merely because in some cases similar rocks have been formed by the metamorphosis of sedimentary strata, or in an eruptive manner. Those who, because a few beds of mica-schist or gneiss have been admitted to be metamorphosed clay-slate or greywacke slate, declare that all mica-schists and gneiss are only altered sedimentary rocks, only metametamorphosed beds of mud, virtually remove the ground from beneath our feet, and limit us to a transcendental succession of sedimentary deposits, which, downward, has no end, or rather no demonstrable commencement; because finally the actual sedimentary origin can neither be recognized nor proved, but can only be maintained as a hypothetical assumption."

"The primitive formation appears to possess quite an extraordinary thickness; and to reach very far down into the depths of the earth. At the same time it shows in a remarkable manner, in those different regions where it comes to the surface, such a general resemblance as regards its rocks, their structure and form of stratification, that one is led from this alone to think that some stupendous process must have taken place over the whole surface of the earth at the same time and in the same manner, and that it is to this process that the primitive formation owes its existence; and even, although it may be so completely covered over in regions of immeasurable extent that in these it is not observed to come to the surface, still we are entitled with complete justice to suppose the existence of an uninterrupted extension of the same, under all the sedimentary and eruptive formations with which we are acquainted.

"The necessity of a primitive formation is besides so apparent that one can scarcely comprehend how its existence could ever be doubted. It appears, in fact, to be a first and indispensable condition, without which the possibility of sedimentary, as well as of eruptive formations cannot be comprehended. The primitive formation has also been, by different authors, entitled the prozoic, azoic or hypozoic formation, because it existed long before the commencement of the first races of animals or plants, and therefore contains not a trace of organic remains, and lies beneath all fossiliferous formations. But all eruptive formations are likewise azoic; the oldest sedimentary formation is likewise prozoic, and the term hypozoic is perhaps a word which does not correspond sufficiently well with the idea intended to be expressed by it."

"It is possible for us to regard the primitive formation perhaps, as the uppermost part of the original solidified crust of our planet; and this supposition has here and there been adopted. We leave, however, the process of their formation undecided, and rest satisfied, in the meantime, with the negative result, that according to the present condition of our knowledge, the primitive formation can neither be a sedimentary formation, in the usual signification of the term, nor yet an eruptive formation, properly speaking. It is however a most remarkable fact, that a few comparatively far younger formations show a surprising similarity to the primitive formation in the structure and architecture of their rocks, (viz., the Münchberg gneiss-formation in Oberfranken, and the protogine formation of the Alps). This fact, as well as the circumstance, that they are almost all cryptogenous or stratified crystalline rocks, which occur, on the one hand, as undoubted primitive, and on the other as newer products, make it advisable to class both together under the common name of the cryptogenous formations, or also of the stratified silicate formations."

"Many, perhaps even the most of the geologists of the present day, are of the opinion that the strata of the primitive formation are very ancient metamorphic sedimentary strata. Until convincing proofs are adduced in support of this view, it may however, only be excused as an attempt to bring incomprehensible phenomena into unison, at least hypothetically, with comprehensible appearances. 'Whereupon,' asks Humboldt, 'do the oldest sedimentary rocks rest, if gneiss and mica-schist are only to be regarded as altered sedimentaay strata?' Cosmos, i., p. 299."

It is very evident from the foregoing, that Naumann leans to the opinion that the primitive formation is the result of the first process of solidification which the fluid globe underwent. He refrains from declaring himself in favor of this idea, principally on the grounds mentioned in another chapter of his "Lehrbuch," a translation of which has already been given in this Journal.* These grounds are the foliated texture of gneiss and its associated rocks, and the highly inclined position of their strata. The first of these phenomena I have already attempted to account for. We shall, in the course of the following remarks, endeavour to ascertain whether the almost vertical position of the primitive strata is also capable of being explained.

In regarding gneiss as an igneous rock, there are, of course, the same difficulties arising from its mineralogical composition, to be explained away, as in the case of granite, but these we intend to postpone considering, until we come to speak of the protrusion of the latter rock. The same mode of explanation adopted in the case of gneiss, would of course require to be resorted to in the case of the schistose rocks associated with it, especially such as mica-schist and hornblende slate. We must not suppose that the latter rock was formed from the same zone of igneous material as the gneiss, but on the contrary, that it is the product of some of the lower zones, brought up to the newly formed crust by cosmical influences, and consolidated on the inner part of the same, subject, of course, to the same influences during its solidification as we have supposed in the case of gneiss, We thus suppose that the first stage of the consolidation of the globe consisted in the formation of a thin crust of stratified rocks; those rocks being now to be found constituting the so-called primitive gneiss formation.

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* Vol. vii, p. 254.

In accordance with the views given in the second part of this paper, of the nature of the process of solidification at present progressing beneath the earth's crust, we must suppose that during the solidification of the first crust, a contraction of the volume of the originally fluid material took place. This view must be adopted on experimental grounds also. Bischof found, in casting a globe of basalt, twenty-seven inches in diameter, that in the centre of the mass, on cooling, a cavity had formed capable of containing half a pint of water. Further, at the Muldner smelting works, near Freiberg, stones are cast of the slag run out of the reverberatory furnaces. They are two feet long, one foot deep and one broad, and when broken after cooling, they are found to contain in the middle irregularly shaped cavities from three to five inches wide, the sides of which are covered with brilliant microscopic crystals.* From these instances it might be expected, that during the first solidification, a vacuum might, to some extent, have been formed beneath the crust of the earth. With the progress of the consolidation the dimensions of the vacuum must have increased, and the power of the crust to support the enormous pressure of the then existing atmosphere must have decreased. We may suppose that ultimately a point was reached, when the crust was unable longer to support the enormous load, and that it then gave way in various places, its fragments sinking down to the fluid interior and floating upon its surface. In this way the first great subsidence of the earth's crust may be reasonably supposed to have taken place. The area of the original globe having however decreased during the solidification, it would be impossible for the fragments of the crust to maintain their original horizontal position. Very likely also the still fluid material beneath the crust would protrude itself through between the fragments, thrusting them aside, and limiting still further the space occupied by the latter. The consequence of this would be, that the fragments would arrange themselves in positions more or less vertical, and, although some of them might still remain horizontal, still highly inclined positions would be the rule. We can even imagine how corrugations of the strata, such as described by Sir William Logan in Canada, and by McCulloch in

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* Leonhard, Hüttenerzeugnisse, p, 186.

Scotland, could be formed under the influence of the various forces here at work. While great areas of the earth's crust must have been dislocated in this manner, it is quite possible that other great areas may have been able to preserve, throughout these convulsions, their originally horizontal position. That part of the fluid material which may have protruded itself through the fractured crust, we may reasonably imagine to have solidified somewhat out of the range of the internal currents, and to have produced the first erupted granites. We may further reasonably suppose that the same fluid material must have penetrated into the interstices between the various fragments of the original crust, and have solidified there. This fractured and re-consolidated part of the crust would then present exactly the same appearance, so far as the relations of the various rocks are concerned, as the primitive strata of Canada, Scandinavia, and the north of Scotland do at the present day. That is to say the strata of gneiss, granite, mica and hornblende schist would be arranged in highly inclined positions, and if in contact with rocks of later periods, the latter would overlie the primitive strata unconformably. This peculiar build of the primitive rocks is characteristic of those districts where they have been admitted to be the oldest rocks on the earth's surface. Thus, in some of the Western Islands of Scotland, the primitive strata are not overlaid by any newer rock; and in Canada the vertical strata of the Laurentian series are in many places covered by the horizontal beds of the Potsdam sandstone. In Norway the outcrops of the highly inclined primary strata frequently occupy areas of several hundred square miles, and, at the outskirts of these areas they are overlaid by fossiliferous strata of the Silurian system. The primitive rocks of Brazil, consisting of gneiss, gneiss-granites, granite, syenite, mica-schist, and hornblende rocks, extend north and south through fourteen degrees of latitude, and have a breadth of 250 geographical miles, in which enormous area, strata inclined from 45 to 70 degrees are alone observable. We cannot suppose that these rocks were originally formed in this position; nor can we reasonably regard them as a system of strata, having, in their original horizontal position, a thickness of upwards of 100 geographical miles. There remains only the explanation given above, that the originally not very thick strata assumed their highly inclined position owing to the lateral pressure to which they were exposed; the latter having been caused, partly by the contraction experienced by the globe in cooling, and partly by the protrusion of igneous matter from beneath the broken crust. An analogous phenomenon may every winter be observed on the St. Lawrence. When the ice shoves, pressure being exerted upon it from higher up the stream, the floes of ice are raised upon their ends, and a confused aggregate of inclined beds is the result; and it is worthy of remark that each of these beds is in itself distinctly stratified, just as are the individual layers of the primary rocks, the cause of this stratification being in each case not entirely dissimilar.

We have thus endeavoured to remove Naumann's principal objections to the igneous origin of the primary stratified rocks. We have next to refer to the objection founded on the mineralogical composition of gneiss, which is the same as in the case of granite. This objection is the presence in it of quartz, which occurs in such a manner, as to indicate that it must have been the mineral which solidified last of all, although it is the most infusible of the constituents of granite. Perfectly well formed crystals of it often, it is alleged, leave their impression on the adjoining feldspar and mica. We have already seen that this is denied by Sartorius von Waltershausen, who also insists that the quartz formed subsequently to the consolidation of the granite, by the action of water, must not be confounded with the original granular quartz, which is never or seldom found crystallized. In spite, however, of this denial, many supporters of the igneous origin of granite consider it necessary to attempt to account for the occurrence of quartz in the manner above stated. The following are the remarks of Naumann on the subject: "Gaudin's experiments have shown that melted silica becomes viscid before it solidifies, and while in this state it may be drawn out into threads like sealing wax. This proves that the temperature, at which it solidifies, lies very far below the temperature, at which it fuses, wherefore this phenomenon has been used by Fournet in support of his theory of the surfusion of silica, the fundamental idea of which theory has also been strongly supported by Petzholdt (Fournet, Compte Rendu, tome xviii. 1844., p. 1050; and Petzholdt, Geologie, p. 313). Moreover Durocher has pointed out that the fusing temperature of silica (perhaps amounting to 2800 degrees C.) is not necessary in order to explain the crystallization of granite, because the silica of the quartz formed, combined with the elements of the feldspar and the mica, a completely homogenous, igneous magma, in order to the fusion of which a temperature approaching the fusing point of orthoclase may have been sufficient. While the feldspar and mica crystallized from this magma, the excess of silica was merely *separated* as quartz.* These two explanations must not be confounded with each other. The surfusion of Fournet differs essentially from the viscosity of Durocher. "En vertu du premier," says the latter philosopher, "une substance peut conserver sa parfaite liquidité, à une température inférieure à son point de fusion. En vertu du second, des substances diverses, chauffées jusqu'à liquéfaction, puis abandonnées au refroidissement spontanné, dans les mêmes circonstances, mettent des temps fort inégaux à se solidifier, celles qui tendent à crystalliser, deviennent solides les premières; celles qui constituent des masses amorphes restent longtemps dans un état plastique analogue à celui de la poix et intermédiaire entre l'état liquide et l'état solide."† When we take into consideration the common blowpipe reaction, in which silica is often separated from a fused bead as a gelatinous skeleton, it would appear to lend considerable support to Durocher's theory.

I here conclude the explanation which I have attempted of the origin of the Primitive formation. I conceive that only one series of rocks is entitled to this appellation. The term primary has often been applied to quartzites and slates of later age; which rocks have been classified by German geologists under the name of the Primitive Slate formation. It is very evident, however, that there can have been but one primitive formation, and since the slates and quartzites above referred to bear evidence of their having been derived frem pre-existing rocks, it would appear incorrect to entitle them primary or primitive. Were it not that geological nomenclature is already sufficiently confused, it would appear much more reasonable to apply the old term of Transition Formation to these rocks; since it is highly probable that during the period in which they were formed, the temperature of the first crust gradually decreased to a temperature at which it was possible for water to exist in large quantity on the earth's surface. We have seen that during the first granitic eruptions, water did not exist on the surface, otherwise rocks of a more or less tufaceous character would have been produced. This conclusion would also seem to be corroborated by the ideas which we must entertain of the high temperature of the newly solidified crust. When the temperature of the latter so far decreased as to admit of the condensation of the water existing in the atmosphere, the rain, which fell upon it, must have been instantaneously evaporated. This rapid condensation and evaporation must have continued through long ages before any considerable accumulation of water could have taken place. Even then such accumulations must have possessed for a long time a boiling temperature, and long ages must again have been necessary before it cooled down to such an extent as to enable animated creatures to exist within it. If to these considerations we add the following, namely that the water condensing upon the heated rocks must have been charged with muriatic and carbonic acids, (the latter at a later stage than the former), it is very plain that the products of the action of the atmospheric influences then, must have been of a character widely different from those produced by the same agencies at the present day. The action of such acidulated water aided by heat must have been much more energetic then than now. This has been already fully recognized by Dr. Hunt. "The solid crust," he remarks, "would afterwards be attacked by the acids, precipitated, with water, under the pressure of a high atmospheric column, and at an elevated temperature; from which would result the separation of a great amount of silica, and the formation of an ocean, whose waters would contain in the state of chlorides and sulphates not only alkalies, but also large portions of lime and magnesia. At a later period, the decomposition of exposed portions under the influence of water and carbonic acid would give rise, on the one hand to clays, and on the other to carbonate of soda. This latter reaction upon the calcareous salts of the seawater must produce chloride of sodium and carbonate of lime. We have here a theory of the source of the quartz, the carbonate of lime and the argillaceous matters of the earth's crust explaining at the same time, the origin of the chloride of sodium of the sea, and the fixation of the carbonic acid of the atmosphere in the form of carbonate of lime."* I may be permitted to remark, that no theory accounts more completely and satisfactorily for the origin of the so-called Primitive Slate formation, than does this. It is surely not too much to assume, that the crystalline character of its rocks has been caused by the nature of the agents then at work, and the influence of the higher temperature and greater atmospheric pressure then prevailing. It is evident that the action of the muriatic acid of the atmosphere *must* have long preceded the action of carbonic acid, since we are almost unable to conceive that the latter gas could exist in water of higher than ordinary temperature. The quartz, the carbonate of lime, and the argillaceous matter above mentioned are peculiarly at home in the Primitive Slate formation, and are comparatively rare in the fundamental gneiss or primitive formation-proper. We have only to refer to the highly quartzose rocks of the Huronian formation, of the Thelemarken quartz formation, and of the so-called primary sandstones of the western islands of Scotland, to show that the separation of quartz on an extraordinary scale must have been one of the first products of the condensation of aqueous vapour on the earth's surface. Moreover, although primary limestones are not of unfrequent occurrence in gneiss, they are of trifling extent compared with the limestones of the so called Primitive Slates. At first of less frequent occurrence, of light grey colour, and crystalline character, and evidently more the result of a chemical precipitation than made up of animal organisms, they pass through various gradations of color, becoming more frequent and of darker color (more charged with carbon) as they grow younger. In the micaceous and the clay slates, which exceed in extent of developement both quartzites and limestones, we find a similar gradual change in their colours and lithological characters; the younger they become the more they are charged with carbon, and the more they resemble slates of more modern formations. The source of this carbon was undoubtedly the atmosphere, where it probably existed free, or was derived from the decomposition of its compounds with other elements. During the period, when the primitive slate rocks were formed, the metallic chlorides were also most probably removed from the atmosphere. This may have given rise to the extensive metallic deposits existing among these crystalline slates.

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* Naumann, Lehrbuch, i., p. 740.

† Bul. de la Soc. Geol. 1849-50, p. 276.

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*Canadian Naturalist, vol. vii., p. 202.

After the abrasion of the material from which the quartzose, micaceous and argillaceous slates resulted, we must suppose that it became deposited in the hollows of the then existing crust, which hollows were most probably occupied by primitive strata lying horizontal or nearly so. Those parts of the first crust, which rose above this primitive ocean, are most likely to have been the highly inclined primitive strata or eruptive masses of granite. If this view be correct then the rocks of our Transition formation must generally have been deposited conformably upon horizontal gneiss, or rocks allied to it.

While the atmospheric agencies, and more especially water, were thus at work upon the surface of the original crust of the earth, the same process of solidification which we formerly referred to, must have been progressing beneath it. The interior of the globe must have experienced a further contraction; and after having resisted for some time, the earth's crust must have subsided, and become fractured and folded in the same manner as the primitive gneiss, though perhaps to a less violent degree. This idea of a gradual contraction of the globe, and the consequent folding of the strata composing the crust, has especially been advocated by French geologists such as Rivière and Constant-Prévost. The latter geologist has the following remarks upon it: "Après des dissidences plus apparentes que réelles, presque tous les géologues tendent à admettre aujourd'hui, que l'enveloppe consolidée de la terre a éprouvé, et éprouve encore, un mouvement centripète contenu, dû à la diminution de chaleur et de volume de la masse intérieure du globe. De ce mouvement il résulte nécessairement, dans l'enveloppe solide, et après une résistence plus ou moins longue, des ondulations, des plissements, des redressements et des ruptures, dont les unes sont produites dans les parties enfoncées, et les autres dans les parties relevées des plis. C'est par ces pentes que sont sorties les matières encore molles sous-jacentes; elles ont traversé les issues qui leur étaient offertes, mais elles n'ont pas brisé les barrières qui les retenaient. Sans doute qu'avec ces mouvements généraux des approchements du sol vers le centre de la planète, le refroidissement a produit des retraits locaux partiels dans les matières refroidies; que la diminution inégale des matières de nature diverse a également donné lieu à des changements relatifs de niveau et à des ruptures quelquefois très-importantes; que souvent aussi le plissement de tables horizontales a pu occasionner des pressions latérales qui ont poussé, de dedans ou en dehors, des matières malléables en sens inverse de celui déterminé par la grande cause première du mouvement, lesquelles matières ont pu redresser, renverser, soulever les lambeaux des strates brisées. Mais ce sont là des faits de détail, des exceptions qui, loin d'infirmer la loi générale, viennent la confirmer, lorsqu'ils sont analysés avec attention et réduits à leur juste valeur."* In describing and accounting for the architecture of the "Terrain gnéissique de la Vendée" Rivière adopts the same theory.†

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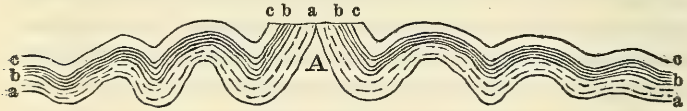
* Constant-Prévost, sur le mode de formation des chaînes de montagnes. Bul. de la Soc. Géol. de France, 1849–50, tome vii, p. 53.

† Bul. de la Soc. Geol., 2 series, tome vii., p. 327.

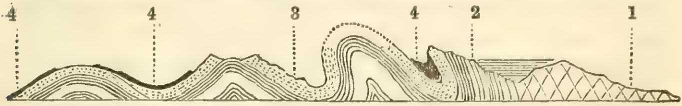
We may now proceed to consider what effects, according to this theory, would be produced on the earth's crust as the same was constituted after the slate rocks above mentioned, and even the so-called greywacke series had been deposited. The slates and sandstones of the latter formation are the oldest rocks which thoroughly resemble, in their lithological characters, the sedimentary deposits of later periods; wherefore we may suppose that at the same time they were formed, the temperature of the earth's surface and the agencies at work upon it somewhat approximated to those of the present day. The portion of the earth's crust least likely to be affected by the subsidences consequent upon the contraction of the globe, may reasonably be supposed to have been the thickest part, that part where vertical strata of gneiss and rocks allied to it, extended deep down into the earth's crust. The part most liable to be fractured and raised into folds, would most probably be the thinnest, or that part where horizontal or but slightly inclined gneiss strata, had been conformably overlaid by micaceous, argillaceous, chloritic and quartzose slates. If we attempt to speculate as to what might be the first consequences of the contraction upon these latter rocks, we would naturally suppose that after a fissure had once been formed, the strata bordering on it would rise in a manner sketched in the subjoined figure.



a. gneiss, b. mica schist, c. clay slate.

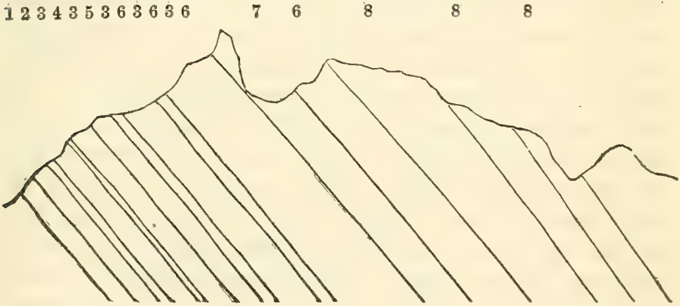
And in reality not a few of the so-called Primitive Slate districts possess an architecture closely analogous to the above ideal section. This is especially the case in the Alps of Salzburg and Upper Carinthia. In this part of the central Alps, according to Credner, a mass of granitic gneiss, drawn out from east to west, forms the centre. On the north as well as on the south side of this mass crystalline slates overlie it. On the north side the dip is at a high angle to the north, and on the south side the highly inclined strata dip to the south. These crystalline slates are divisible into three groups, the lowest consisting of common and calcareous mica-slate, the middle group of chlorite and talc slates, and the upper group of common and calcareous clay-slate. Moreover the structure of the metamorphic rocks of eastern North America, and also of the slate districts north of the Mjo'sen in

Norway, would seem greatly to resemble the above ideal section, if we suppose one half of the same to be obliterated. The following is a section of the Alleghany chain according to Rogers :*



1. Gneiss, mica slate, &c.
2. Silurian system (so-called metamorphic strata).
3. Devonian "
4. Carboniferous "

The above delineated structure of the slate rocks would have experienced a modification, in the event of igneous rocks having been protruded through the fissures formed by these movements of the earth's crust. These igneous rocks would most easily be protruded at the point marked A in the sketch first above given. If we imagine a granitic mass to be erupted at the point so marked, we have then a section resembling in its general features the build of the so called primitive rocks in many parts of the Alps of Switzerland, in the Saxon Erzgebirge, in Hungary, and in the gneissoid region of La Vendée, above mentioned. The following is a section given by Beudant, of the structure of the schistose rocks in the county of Gömör in Hungary.†



1. Granite.
2. Gneiss.
3. Mica-schist.
4. Greenstone.
5. Limestone.
6. Clay-slate.
7. Iron ore.
8. Schistose greywacke and limestone.

Here the primitive and slate strata rest upon the granite in the following order: 1st gneiss, 2d mica-schist, 3d clay-slate. The mica-schists and clay-slates in the districts above mentioned never occur overlying the gneiss strata unconformably. On the contrary, they are so intimately connected that a gradual transition is generally observed to take place between them; the gneiss gradually changes into mica-schist, the latter gradually becomes less crystalline, and finally argillaceous and chloritic rocks result.

---

* Naumann, Lehrbuch, i, 994.

† Voyage en Hongrie, Atlas, Fig. 5.

A further modification of the above type of the structure of the slate rocks occurs when the granite is so extensively protruded as to overlie the gneiss strata, or when the latter have not been forced up to the surface. In this case the micaceous or argillaceous slate is found immediately reposing upon or at least in contact with the granite. In this manner the mica-schist with interstratified limestones, north of Drontheim in Norway, overlie the granite of Vestfjord, and in this way also the killas or clay-slates of Cornwall lean upon the granite of Dartmoor. In the latter cases no lithological transitions are observable between the slates and the granite, while in former cases, where gneiss is interposed between them, the transition from the latter rock to granite is distinctly observable. This phenomenon, it will be observed, however, is not inconsistent with the explanation here given of the origin of these rocks.

I have thus attempted to explain some of the most remarkable phenomena connected with the primary rocks. It will be observed that in so doing, I have tried to elaborate and combine together many of the ideas expressed by different geological authorities. I am far however from maintaining that the theory here given is adequate to account for all the facts observable in connection with these rocks. Nor is it at present necessary that this explanation should be perfect. There must be in geology as in other sciences, obscure problems always awaiting solution. The best apology which I can offer for presuming to attempt an explanation of the enigmatical phenomena connected with the primary rocks, is in the following words of McCulloch:* "The human mind is so constituted that it cannot rest content with facts. If it posesses innate propensities, the investigation of causes is assuredly one of them. The very geologist who disclaims all theory has his own; the lowest of the vulgar desire reasons. The laws which govern the phenomena of nature force themselves irresistibly on our attention. They are strictly involved with the analogies which regulate all our reasonings and direct our observations; and without them we cannot proceed a step on firm ground. They distinguish the philosopher from the empiric, and combine scattered observations into a body of useful and rational science. Even in the science of nature, as in that of numbers, the assumption of imaginary or erroneous laws, leads to the discovery of the truth. The history of astronomy is in itself a lesson to those who ignorantly undervalue the pursuit of general laws. Bewildered in spheres and vortices, it arose, as in a moment, complete, from the theory of gravitation.

---

* System of Geology, vol. i, p. 485.

"Hence the consideration of secondary causes, forms, not only a legitimate, but an essential part of geological science. That science, like all others, comprises the history of all the facts which it involves; and from these, it establishes certain general analogies. Ascending a step higher it declares the laws which have regulated, and will continue to regulate, all the phenomena of the globe; and thus finally establishes a legitimate theory of the earth."

No trace of organic remains has been discovered in these micaceous, chloritic or argillaceous slates, nor even in the limestones associated with them. The adherents of the metamorphic hypothesis attempt to account for this by supposing that the fossils have been obliterated by the agencies which have effected the alteration. But even in the greywacke slates and sandstones, traces of life are rare; and it is only in the very newest strata of that series, that they become at all frequent, and then they belong to the inferior grades of animal organisms. That the air-breathers, recently described by Dr. Dawson, first make their appearance in the coal-measures, may be regarded as a proof of the absence of free oxygen from the atmosphere which existed during the deposition of the Lower Silurian rocks. Not until the carbonic acid was to a great extent removed from the atmosphere by the luxuriant vegetation of the coal period, and its place taken up by oxygen, was it possible for air-breathers to exist. The extraordinarily rich vegetation of that epoch was no doubt stimulated by the immense quantities of carbonic acid in the atmosphere, and the exceedingly warm climate which then prevailed over the whole surface of the earth. This warm climate, we are justified in supposing, was caused more by the radiation of heat from the interior of the earth, than by solar influence. So that it is possible to trace a connection between the phenomena of internal heat and the characteristic strata of the carboniferous system, and between that series of rocks and the constitution of the primitive atmosphere. In this, as in much of what has been stated in this paper we recognise how intimately linked together all natural phenomena and all departments of science are. The various natural sciences are like the crystalline rocks; they graduate into each other, forming, when properly interpreted, a compact, well ordered and harmonious whole.

And while we study and recognise all this, surely it behoves us to acknowledge reverently the great Author of all. The mere external features of primitive districts inspire us with feelings of wonder and awe. Standing on the summit of Gaustafjeld, we can look northward over hundreds of square miles of primitive rocks, forming there the broad, barren plateau of Hardangerfjeld. As far as the eye can reach there is spread out a desert of rocks broken only by the lakes, which form the sources of the turbulent streams that leap down into the fiords of the west and south, or by valleys with precipitous sides, which seem as if hewn out of the solid rock of the plateau beneath the level of its general surface. The scanty and stunted vegetation heightens the desolation of the scene, but nevertheless its rugged grandeur causes the observer to be deeply impressed with his own insignificance, and with the awful power of the Originator of the universe. But how greatly is this feeling deepened when the architecture of these rocks and the mode of their formation is considered. Here we feel our utter littleness even more forcibly; but we at the same time gain some idea of that series of processes and revolutions by which the earth was fitted for man, and of the power and wisdom of the great Designer who caused our present beautiful earth to emerge from the chaos of the primitive period. We also learn enough to exclaim with the Psalmist, "Of old hast Thou laid the foundations of the earth."

Acton Vale, C. E.
12th January, 1864.

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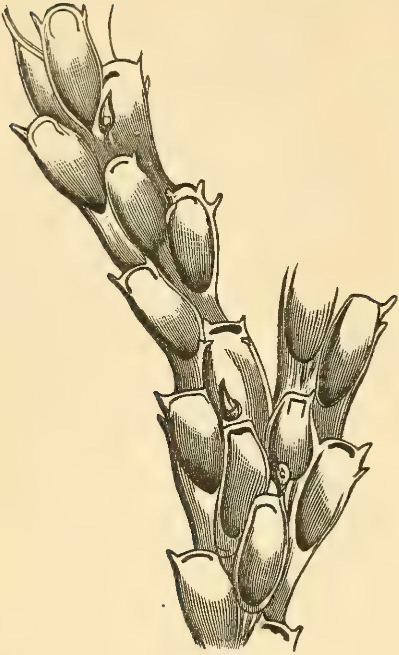

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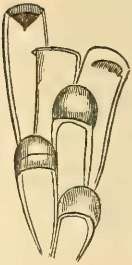

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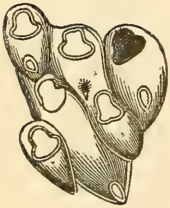

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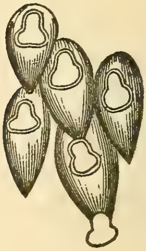

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2 M. solida.

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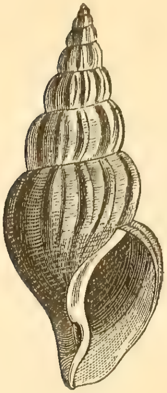

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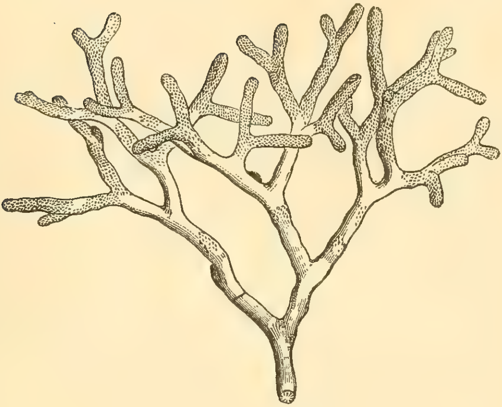

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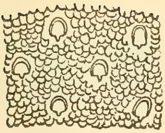

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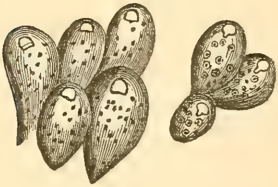

1.

1 L. producta.

5 M. subgracile.

6 B. cretaceum.

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Douglas' do.
Richardson's do.
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Hare-Squirrel.
Black Squirrel.
Hoary Marmot.
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